SoC Design Skills: Collaboration Builds a Stronger Design Team

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SoC requires special skills:

“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”

Outline of the Talk:

1. SoC & the Pittsburgh Digital Greenhouse
2. PDG Academic Partnership
   - Collaborative SoC Certificate Program
   - Identification of SoC Skills
3. Core Skill Set and Curriculum Issues
4. Summary

What is the PDG?
A Not-for-Profit, Economic Development Initiative

PDG Mission:
   - Create jobs related to chip design
Technology Focus:
   - System on Chip (SoC), VLSI

Market Focus:
   - Digital Multimedia and Digital Networking
Carnegie Mellon, Penn State, and University of Pittsburgh are collaboratively developing an SoC Masters Degree program

- Taskforce created with representation from each University and coordination from the PDG
- Essential SoC Skills and common core curriculum defined by all three universities
- Specialized courses being developed according to faculty talents and interests at each school
- Major Design Experience course will provide capstone experience with Industrial CAD tool flow
Collaborative SoC Certificate Program

- Taskforce has defined base SoC Skill-Set. New SoC-related courses identified for development and existing courses identified for enhancement
- Cross-registration & distance education infrastructure being developed to support course sharing
- Shared Industrial CAD tool flow and libraries for common “major design experience” course

Collaborative SoC Curriculum Plan

1. Core Curriculum
   - Students enter and complete core (breadth) curriculum at home institution

2. Specialized Courses
   - Students may cross register between member schools
   - Advanced courses taught by faculty in their area of expertise

3. SoC Design Experience
   - Major SoC design project
   - Central support (Digital Sandbox)
   - Industry / University interaction

4. MS with SoC Certificate
   - From home institution
   - Extension to undergraduate SoC specialization option
Need for Collaboration

- Reduce the overall cost of supporting independent programs at each university:
  - shared infrastructure for design support
  - shared design tool flow, libraries, instructional and laboratory materials
  - distributed development & teaching of SoC courses to cover the breadth of skills, and
  - leverage of extensive existing academic programs

- Achieve economies of scale to more efficiently educate students in SoC state of the art

Core Skills for SoC Design

SoC Taskforce: cataloged available courses at each university, determined which would support a suitable SoC skill set, and is proposing a set of new courses that will enhance that support

Skill Categories

1. SYSTEM (SoC) DEVELOPMENT SKILLS
2. STRUCTURAL (HW & SW) DESIGN
   - Software Architecture
   - Hardware Architecture
   - Hardware IP Authoring & Delivery
   - Support Skills for SOC applications
3. NON-TECHNICAL SKILLS
### System + SW Design Skills

#### SoC System 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

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

### Structural Chip Design Skills

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

#### HW IP Authoring / Delivery:
- Interface Standards-Based Design
- Design for Multiple Use / Re-Use
- Logic and Mixed-Signal Design
- Analog and RF Design
- Design for X (power efficiency, testability, manufacturability, …)
- IP Qualification/Compliance
- Formal Verification
- Interface Design; Interface-Driven Integration
- Functional and Timing Verification
- Synthesis (Soft & Firm VCs)
### SoC Support Skills

<table>
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<tr>
<th>SoC Application Support:</th>
<th>Non-Technical:</th>
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<tr>
<td>Human/Computer Interaction</td>
<td>IP Licensing; legal and business issues</td>
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<tr>
<td>Control &amp; Communication</td>
<td>Multi-Disciplinary Design Teams</td>
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<td>Computing / Digital Signal Processing</td>
<td>Verbal and Written Communication</td>
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<td>Algorithm Development</td>
<td>Entrepreneurship</td>
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<td>Network Protocol Development</td>
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<td>Image/Voice Processing</td>
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<td>Multi-/Concurrent Processing; Real-Time Programming</td>
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### Candidate New Courses

(as identified by the SoC Taskforce):

i. IP Creation for Reuse  
ii. System Level Design and IP Use  
iii. Real-Time / Embedded / Fault-Tolerant OS  
iv. Constraint Aware / Retargetable Optimizing Compilers  
v. Power Efficient System Design  
vi. RF, Analog, and Mixed Signal Design  
vii. Sensor and Actuator Interfaces  
viii. SoC Verification
SoC Certificate Program

Continuing Education Initiatives

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Digital Sandbox: role in SoC Curriculum Major Design Experience

What is the End Goal?
- Self-sustaining industry-based SoC design flow in each University’s curriculum?
- Enhanced faculty, curriculum, collaboration
- Each University has SoC MDE Course + necessary HW/SW + Industry Flow

Fall 2001 SoC Curriculum Startup
- Plan for pilot MDE course in Sp’02
- Local (CMU & Pitt student) issues
- Remote (PSU) issues. CUSeeMe +PictureTel remote collaboration

Academic Sandbox
- CAD Flow/Lib. Dev.
- HW and SW support
- CAD Tool support
- Major Design Exp.
- Faculty role?

CMU
Pitt
PSU

CMU HW/SW, MDE, flow
Pitt HW/SW, MDE, flow
PSU HW/SW, MDE, flow

Digital Sandbox: role in SoC Curriculum Major Design Experience

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Summary & Status:

- On Track for Fall ‘01 SoC Certificate Program kick-off
- First Major Design Experience course prototype run in Spring ‘02
- Digital Sandbox start-up in progress
- Expanding SoC faculty at member Universities will help the program grow
- Continuing support from Greenhouse, Commonwealth of PA, PDG Member Companies, …

Certificate in SoC Design

Upon the recommendation of the Carnegie Mellon University Electrical and Computer Engineering Department faculty, this certificate is awarded by The Pittsburgh Digital Greenhouse in cooperation with Carnegie Mellon University, The Pennsylvania State University, and The University of Pittsburgh, to:

Jane Q. Student

in recognition of completion of the degree of Master of Science in Computer Science and Engineering at Carnegie Mellon University, together with special System-on-a-Chip Certificate course work and design project requirements.

Signature

Date

Pradeep Khosla, Dowd Prof. of Engineering & Robotics; ECE Dept Head
Department of Electrical Engineering, Carnegie Mellon University

Signature

Date

Dennis Yablonsky, President/CEO, The Pittsburgh Digital Greenhouse