CHIPDESIGN – FROM THEORY TO REAL WORLD

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Overview

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- Seminar Description
- The Project
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  - ASIC Manufacturing and Testing
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Introduction

- University electrical engineering lectures
  - Computer architecture
  - ASIC design
  - Fundamentals of Microelectronic

- Practical training at universities
  - HDL digital design courses limited to FPGA-examples
  - High expenses and experience for EDA-tools required
  - Design issues not included in small projects

- How to provide a suitable solution?
ChipDesign Seminar

- Project-oriented ASIC design seminar
  - 1999-2002 : Least Cost Router
  - 2003-Today : 8-bit RISC Microcontroller

- Motivation: “From theory to real world”

- Focus
  - Practical knowledge
  - Teamwork experience

- Goal
  - Chip manufacturing
Seminar Description: General

- Extend theoretical study by practical aspects
- Duration: 15 week
- ~24 Students
  - Electrical engineering and computer science
  - 3rd - 5th year with bachelor or compatible degree
- Supervision
  - Guaranteed by members of the research staff (tutors)
- Equipment provided by the university
  - Workstations, EDA tools, communication platform,…
Seminar Description: Focus

- **Technical skills**
  - Design of hardware architectures
  - Hardware description language (verilog)
  - Verification strategies
  - Fundamentals of integrated circuit: Backend

- **Social skills**
  - Team work (4 students)
  - Responsible for a subtask of the overall project
  - Status meetings and presentations
Seminar Description: Learning Approach

- Self-regulated learning
- Knowledge, Student Process and Project
- One group (max. 4 students), one tutor, one task
Specific tutorials synchronized with design process

Status meeting every week
The Project: LCR Design Concept

- Least Cost Router
  - Topic from 1999 to 2002
  - Controller for choosing the cheapest telephone provider
  - Modules:
    - keyboard interface
    - display controller
    - synthesizer for a loudspeaker
    - central control unit

- Problems:
  - Dedicated hardware with limited functionality
  - FSM-based modules with strong dependencies
The Project: *IMS-micro* Design Concept

- **8-bit RISC microcontroller**
  - Introduced in 2003
  - Programmable hardware design
  - ATMEL AVR 90S8515 instruction set compatible

- **Advantages:**
  - Education on system level aspects, e.g. computer architecture and low-level software programming
  - Sophisticated modules with fewer dependencies
The Project: Phase A (W0 – W7)

- **Module Implementation**
  - *Instruction Decoder (given)*
  - Group 1. I2C interface
  - Group 2. SRAM Controller and Pin Mapper
  - Group 3. UART Controller
  - Group 4. Timer and I/O Ports
  - Group 5. Register File and PC Unit
  - Group 6. ALU and Address Decoder

- **Tutorials**
  - W1 – Verilog-HDL tutorial
  - W2 – Writing test-benches. Functional verification
  - W3 – Logic Synthesis tutorial
The Project: Phase B (W8 – W13)

- Top-level design
  - Sub-module integration
  - Synthesis
  - Backend
- Top-level verification
  - Simulation environment
  - Assembler programs
  - In-circuit emulation
- Technical documentation
- Social skills: Student communication
The Project: Phase C (W14)

- Extended top-level verification
  - Code coverage (ModelSim)
  - Functional coverage (Automatic test programs)
- Critical path and architecture optimizations
The Project: After the Seminar

- ASIC manufacturing
  - 2003, 2005 and 2006
  - Europractice / Austriamicrosystems AG
  - 0.35 µm CMOS
  - One chip per student

- Testing
  - *IMS-micro* evaluation board
  - Maximum running frequency: 60 MHz (2006)
Evaluation (I)

- Seminar scheduling concept
  - Synchronized with the *IMS-micro* design
  - Tutorial-based

- Supervision concept
  - One tutor per student group
  - Status meetings

- Student prerequisite
  - Pre-selection of participants by written exams
  - Examination results used to divide students into groups
Evaluation (II)

- **IMS-micro vs. LCR**
  - **LCR**
    - ✗ dedicated hardware with limited functionality
    - ✓ clearly structured modules with similar complexity
    - ✗ only FSM-based modules with strong dependencies
  - **IMS-micro**
    - ✓ programmable hardware design
    - ✓ more sophisticated design with fewer dependencies
    - ✓ knowledge of the whole architecture required
    - ✓ higher acceptance due to a practical design

- **IMS-micro** is more suited to teach students all aspects of the design process
Conclusions

- Project-oriented ASIC design course
  - Tutorials and practical work separated
  - Whole integrated circuit design flow
  - Improve social skills by giving responsibilities

- Pros vs. cons of ChipDesign
  - Programmable hardware design
  - System level aspects
  - Elevated cost (equipments, EDA-tools, tutors,…)

- After the project, students are ready to design integrated circuits of higher complexity