A Platform FPGA-based Hardware-Software Undergraduate Laboratory

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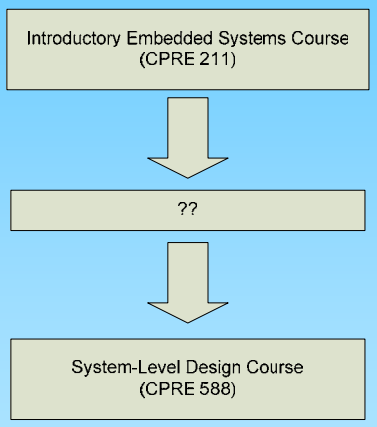
This work was partially supported by the National Science Foundation under grant no. EEC-0088071 and by the Rockwell Collins Foundation.

Overview

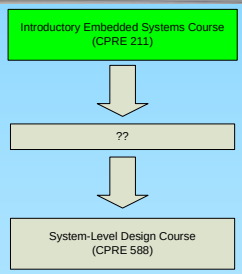
- **Background**
  - Need for a new embedded systems design course
- **Course Description**
  - Learning objectives
  - Available resources
- **Laboratories**



CPRE 211

"Microcontrollers & Digital Systems Design"
http://class.ee.iastate.edu/cpre211

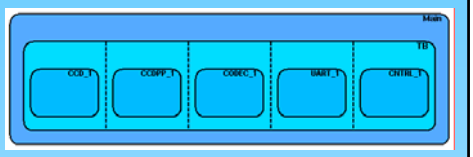
- **Powerbox**
  - 32-bit PowerPC
  - Code Warrior IDE
- **Learning Objectives**
  - Assembly and C programming
  - Interrupts, ISRs
  - I/O subsystems
  - Basic debugging
- **Resources**
  - *CprE 211 – Introduction to Microcontrollers Lecture Notes*, Aaron Striegel, Diane Rover

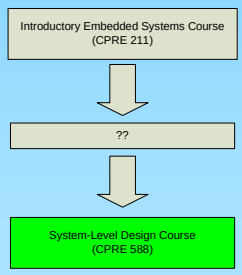


CPRE 588

"Embedded Computer Systems"
http://class.ee.iastate.edu/cpre588

- **System-level Design**
  - SpecC / SCE environment
    - UCI and www.specc.org
  - SystemC
    - www.systemc.org
- **Learning Objectives**
  - System-level design of embedded systems composed of both hardware and software
  - Design experience using contemporary high-level methods and tools
- **Resources**
  - *SpecC: Specification Language and Methodology*, Daniel D. Gajski et. al.





Need to Bridge the Gap

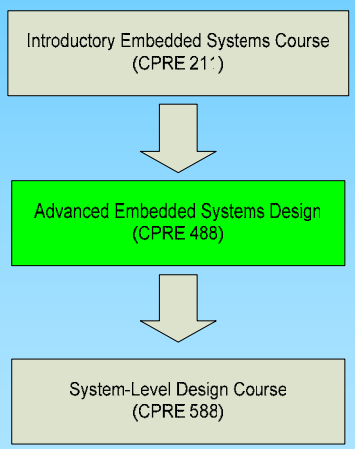
- **Missing Experience**
  - Performance analysis and optimization
  - Hardware accelerators
  - DMA
  - Caching considerations
  - RTOS
  - Relocatable code
  - Advanced debugging
  - Networked embedded systems
- **These topics motivate system-level design**

CPRE 488

"Embedded Systems Design"

http://class.ee.iastate.edu/cpre488

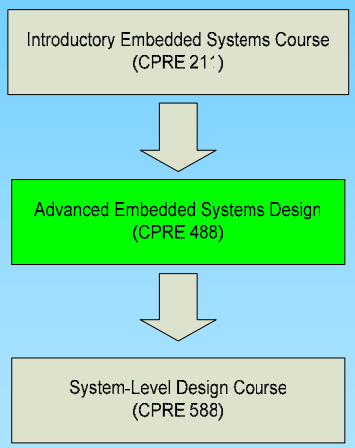
- **Advanced Embedded Systems**
  - "Platform" FPGA
    - "Hard IP" PowerPC core
    - "Soft IP" FPGA fabric
  - Explore HW/SW topics
- **Learning Objectives**
  - Integration of embedded hardware, software and operating systems
  - Familiarity with modern HW/SW tools
  - Development methodology
  - Power/performance analysis



CPRE 488

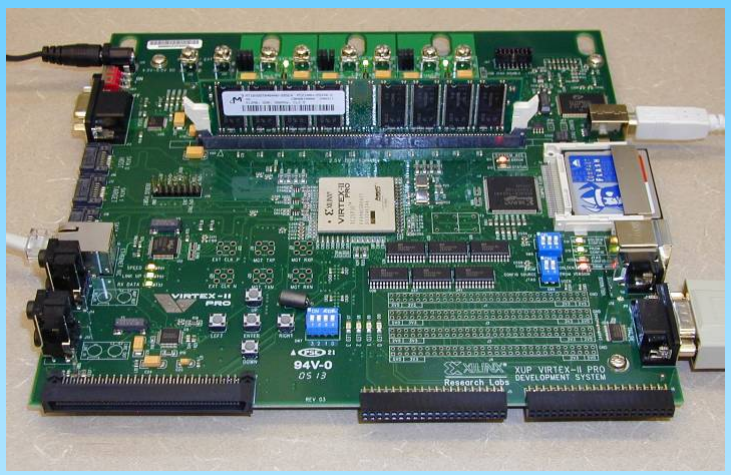
"Embedded Systems Design"
http://class.ee.iastate.edu/cpre488

- **Resources**
  - *Computers as Components*, Wayne Wolf
- **Prerequisites**
  - CprE 305 – Computer Organization and Design
- **Recommended**
  - CprE 308 – Operating Systems, Principles and Practice
- **Senior-level course**



CPRE 488

Embedded Systems Design



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- **ESDL – Embedded Systems Design Laboratory**
  - 12 seats / 12 students
    - Xilinx ISE/EDK toolset
  - Sandbox machines
    - Senior design and graduate study
    - Codesign tools
    - Additional hardware

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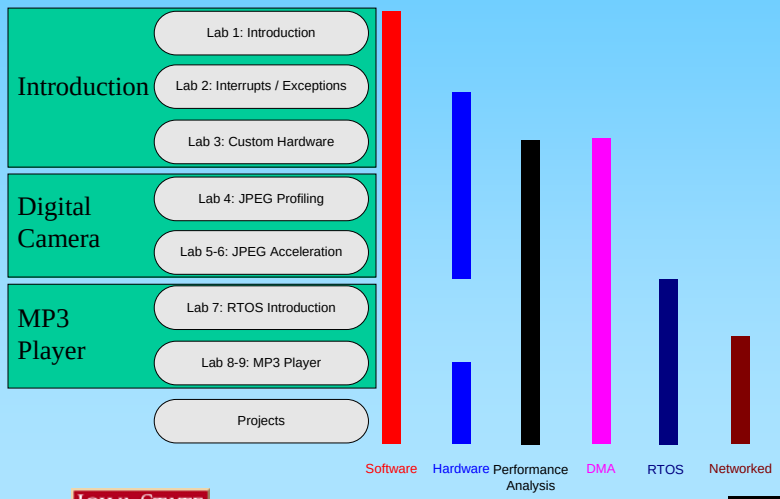
Laboratory Layout



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Laboratory Layout

- **Introduction**
  - Lab 1
    - Simple software project – familiar to students
  - Lab 2
    - Review interrupts, ISRs
    - Add a simple hardware timer
  - Lab 3
    - Simple HW accelerator – Matrix Multiplication
    - Profile software
    - Simple accelerator from scratch
      - Learn cost of communication overhead
    - Matrix multiplier given

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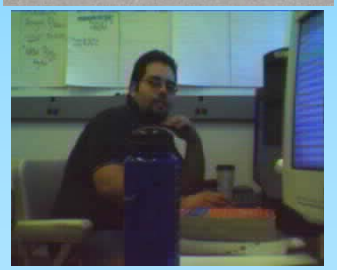
Laboratory Layout

- **Digital Camera (Labs 4-6)**
  - Profile software JPEG encoder
  - Fixed-point refinement
  - Students are responsible for modifying and integrating base hardware JPEG encoder



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- **MP3 Player (Labs 7-9)**
  - Programming/debugging under an RTOS using VxWorks
  - Real-time requirements

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Labs / Lectures

Introduction	Lab 1: Introduction Lab 2: Interrupts / Exceptions Lab 3: Custom Hardware	Lecture 1: Introduction Lectures 2-4: HW/SW System Architecture Lectures 5-8: Accelerated Systems, Design Examples
Digital Camera	Lab 4: JPEG Profiling Lab 5-6: JPEG Acceleration	Lectures 9-10: Common I/O devices, bus and memory Lectures 11-13: Analysis and Optimization
MP3 Player	Lab 7: RTOS Introduction Lab 8-9: MP3 Player	Lectures 14-16: Embedded Operating Systems, IPC Lectures 17-18: Distributed Architectures, Power Management
	Projects	Lectures 19-20: Networked Embedded Systems Lectures 21-24: More Design Examples / Methodologies

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Conclusion

- **CprE 488X – Fall 2005**
  - 26 students enrolled
  - Students learn advanced topics in embedded system design
  - May enhance student interest in graduate courses
  - Lots of possibilities for future improvements to the lab
- **Course and lab development observations**
  - Changing technologies vs. stable technologies
  - System level vs. component level

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Questions