EEL4720/5721 Reconfigurable Computing (dual-listed course)

Department of Electrical and Computer Engineering
University of Florida

Fall Semester 2017

Catalog Description: *Prereq: EEL4712C or EEL5764 or consent of instructor.* Fundamental concepts at advanced undergraduate level (EEL4720) and introductory graduate level (EEL5721) in reconfigurable computing (RC) based upon advanced technologies in field-programmable logic devices. Topics include general RC concepts, device architectures, design tools, metrics and kernels, system architectures, and application case studies. Credit Hours: 3

Prerequisites by Topic: Fundamentals of digital design including device technologies, design methodology and techniques, and design environments and tools; fundamentals of computer organization and architecture, including datapath and control structures, data formats, instruction-set principles, pipelining, instruction-level parallelism, memory hierarchy, and interconnects and interfacing.

***Instructor*:** Dr. Herman Lam

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Teaching Assistants:

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Class lectures:

- MWF 3rd period, NEB 100

Required textbook: none

References:

§ Reconfigurable Computing: The Theory and Practice of FPGA-Based Computation, edited by Scott Hauck and Andre DeHon, Elsevier, Inc. (Morgan Kaufmann Publishers), Amsterdam, 2008. ISBN: 978-0-12-370522-8

§ C. Maxfield, *The Design Warrior's Guide to FPGAs*, Newnes, 2004, ISBN: 978-0750676045.

§ Research papers

§ Vendor documentation

EEL4720 Grading:

- Mid-term: 30%
- Final exam: 30%
- Labs: 15%
- Project: 25%

EEL5721 Grading:

- Mid-term: 30%
- Final exam: 30%
- Labs: 15%
- Project/Research Paper: 25%

There are no scheduled makeup tests. Makeup tests are handled case-by-case, only for documented illness and emergencies.

Course Objectives: Students will gain fundamental knowledge and understanding of the principles and practice in reconfigurable architecture and computing through class lectures and discussions, reading assignments, homework, lab experiments, and a project.

Course Topics:

I. General overview

- Goals and motivations
- History, state of the art, future trends
- Basic RC concepts and related fields of study
- Performance, power, size, and other metrics

II. RC devices and architectures

- FPGAs in general
  - Xilinx Zynq 7000 family programmable SOC (system on chip) in particular - hybrid device with ARM + FPGA architecture
- RC architectures in general
- ZedBoard platform
  - Zynq®-7000 All Programmable SoC XC7Z020-CLG484-1
  - Other key components in more detail
- Novo-G reconfigurable supercomputer
  - GiDEL board
- Other RC platforms
  - Amazon EC2 F1 Instances
  - Microsoft Catapult

III. Design tools and languages

- Hardware description languages, review VHDL
- Xilinx Vivado
- Synthesis, PAR, simulation, debug tools
- High-level synthesis (HLS) languages and tools
  - OpenCL, Convey Hybrid Threading Tools, C-to-gates languages

IV. RC application development

- Compute models and system architectures: parallelism, systolic arrays, pipelining, optimizations, bottlenecks
- RC application domains and case studies
  - BioRC (computational biology), FinRC (computational finance), DSP (signal and image processing), others
- Other topics
  - Hardware/software partitioning, numerical analysis, performance analysis and prediction, etc.

VI. Special topics in RC (guest lecturers from CHREC projects)

- BioRC, FinRC, DSP projects
- Behavioral emulation of future-generation computing systems
- High-level synthesis (HLS) development & studies
- Hybrid Memory Cube (HMC) in RC
- Device and app characterization
- Partial reconfiguration

Lab Experiments: A series of laboratory experiments (spanning the first half of the semester) will be assigned in synchronization with the topics covered in class lectures.

Research Project: Students will form teams of two to four students each and undertake a research project (on a topic subject to instructor approval) exploring fundamental issues in reconfigurable computer architectures, systems, and applications. This project will span the second half of the semester and provide students the opportunity to more deeply explore fundamental issues in RC. Students enrolled in the graduate section of this course will undertake a significantly broader and deeper topic or role than those in the undergraduate section. The culmination of each project for a graduate student will be a clear and concise technical report suitable for publication discussing project concepts, development, experiments, results, and analyses. The most important outcome of each project and report will be the research results that are achieved, analyses rendered, and conclusions drawn with demonstrable insight.

Software:

- Xilinx Vivado WebPack

Equipment:

- Students will have remote access to Zynq-7000 ZedBoards installed on departmental servers.

Honesty Policy: All students admitted to the University of Florida have signed a statement of academic honesty committing themselves to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action. This statement is a reminder to uphold your obligation as a UF student and to be honest in all work submitted and exams taken in this course and all others. Every assignment and exam is subject to the requirements stated in the Academic Honesty Student Guide . The items listed in the Academic Honesty Guidelines in that document will be strictly enforced.

Accommodation for Students with Disabilities: Students requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the Instructor.

UF Counseling Services: Resources are available on-campus for students having personal problems or lacking clear career and academic goals. The resources include:

- University Counseling Center, 301 Peabody Hall, 392-1575, Personal and Career Counseling.
- SHCC mental Health, Student Health Care Center, 392-1171, Personal and Counseling.
- Center for Sexual Assault/Abuse Recovery and Education (CARE), Student Health Care Center, 392-1161, sexual assault counseling.
- Career Resource Center, Reitz Union, 392-1601, career development assistance and counseling.

Software Use: All faculty, staff and student of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the

individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.