ECE 506 - Reconfigurable Computing
Spring 2018

Course Information

Class Hours:	TTh 9:30-10:45
Instructor:	Ali Akoglu
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Email:	akoglu@ece.arizona.edu
Office Hours:	TTh 4:00 PM – 5:00 PM, or by appointment
Course Page:	Course will be managed on D2L

Pre-requisites:
Digital design, programming language (C is a must, VHDL/Verilog knowledge preferred but not required)

Text-book: (Optional) Reconfigurable Computing: The Theory and Practice of FPGA-Based Computation by Scott Hauck, André DeHon and other reading material will be either presented in the class or available as online papers.

Course Format and Teaching Methods: Lecture, group project, in-class discussion, online discussion, web-delivered content and assessment.

Important dates (for drop/withdrawal):
Last day to drop a course without a W: September 4, 2017
Last day to withdraw from a class online through UAccess: October 29, 2017.

Philosophy
"I never did anything by accident, nor did any of my inventions come by accident; they came by work." Thomas Alva Edison.

- Read before the class
- Participate and ask questions
- Manage your time (3 hours outside class for each credit hour)
- Start working on assignments early

Course Objectives and Expected Learning Outcomes: By the end of this course, the student will be able to:

1. Understand the fundamentals of the reconfigurable computing and reconfigurable architectures
2. Articulate the design issues involved in reconfigurable computing systems with a specific focus on Field Programmable Gate Arrays (FPGAs) both in theoretical and application levels
3. Understand the performance trade-offs involved in designing a reconfigurable computing platform with a specific focus on the architecture of a configurable logic block and the programmable interconnect
4. Discuss the state of the art reconfigurable computing architectures spanning fine grained (look up table based processing elements) to coarse grained (arithmetic logic unit level processing elements) architectures.
5. Understand both how to architect reconfigurable systems and how to utilize them for solving challenging computational problems.

Relationship to Student Outcomes: ECE 506 contributes directly to the following specific Electrical Engineering and Computer Engineering Student Outcomes of the ECE Department:

a. an ability to apply knowledge of mathematics, science, and engineering (High)
b. an ability to design and conduct experiments, as well as to analyze and interpret data (High)
c. an ability to design a system, component, or process to meet desired needs within realistic constraints (High)
d. an ability to identify, formulate, and solve engineering problems (High)
e. an ability to communicate effectively (Medium)
f. a recognition of the need for, and an ability to engage in life-long learning (Medium)
g. a knowledge of contemporary issues (High)
h. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. (High)

Topics Covered

- Introduction to Reconfigurable Computing (1 week)
- FPGA Architectures (2 weeks)
- FPGA Design Cycle
    - Technology-independent optimization (1 week)
    - Technology Mapping (1 week)
    - Placement (1 week)
    - Routing (1 week)
- Coarse-grained Reconfigurable Devices (1.5 week)
- Reconfigurable Computing Applications (2 weeks)
- Multi-FPGA Systems (1 week)
- FPGAs vs. Multicore architectures (1 week)
- Advanced Topics: (1.5 weeks)
    - Dynamic Reconfiguration
    - Partial Reconfiguration
    - 3D FPGAs

Class/Laboratory Schedule:

- Course involves simulation/programming based assignments and project activities.
- Two 75-minute lecture sessions per week.
- Class **activities** will involve **reading assignments**, **quizzes**, and 1 comprehensive **exam**
- Semester long project to be completed in phases

Course Description

In this class, we investigate the state-of-the-art in reconfigurable computing both from a hardware and software perspective; understand both how to architect reconfigurable systems and how to apply them to solving challenging computational problems. The purpose of this course is to prepare students for engaging in research on reconfigurable computing.

Scientific community has started exploring reconfigurable computing as a new and innovative technology for accelerating parallel computing. Today, in sheer density state-of-the-art reconfigurable devices are outpacing the microprocessor industry. Thus, they have the capability, especially aggregated on specially designed printed circuit boards, to become self-contained, high-end supercomputers. Moreover, their flexibility raises the possibility of meta-architecture; "morphing" hardware configurations with software as needed to improve efficiency, robustness, security and capability on-the-fly.

Initially, we review in detail the basic building blocks of most reconfigurable computers. Characteristics of FPGA architecture such as the organization of device logic and interconnection resources are examined

to quantify hardware limitations. These physical limitations are then contrasted with computer-aided design issues such as the selection of circuit component locations in devices (the placement problem) and subsequent circuit interconnection between components (the routing problem). While discrete FPGA devices offer an abundance of usable logic, most current reconfigurable computing applications require hardware configurations of multiple FPGAs and memory components organized in a computing system. We then focus on the architecture for existing multi-FPGA systems and on compilation techniques for mapping applications described in a hardware description language to reconfigurable hardware. We will explore the question of "What makes an application suitable for reconfigurable computing?". We evaluate the FPGA based application acceleration with the emerging multicore architectures from the perspectives of price/performance and performance/watt. Specific contemporary reconfigurable computing systems are examined to identify existing system limitations and to highlight opportunities for research in dynamic and partial configuration areas. Assignments will allow students to gain hands on experience in FPGA design cycle and programming paradigms (verilog/hdl). Semester long application and experimentation oriented project will give the students the opportunity to explore state of the art research topics in this field.

Reading, Quizzes and Participation

- Weekly reading assignments will involve review of published studies related to that topic of discussion that week. Completing the reading assignment will be mandatory.
- Quizzes will be used for checking whether students have completed the reading assignment prior to the class or not. Reading assignments will be posted on the D2L.

This term we will be using Piazza for class discussion. The system is highly catered to getting you help fast and efficiently from classmates, and myself. Rather than emailing questions, I encourage you to post your questions on Piazza. If you have any problems or feedback for the developers, email team@piazza.com. Find our class page at: https://piazza.com/arizona/spring2018/ece506/home

- Piazza participation (responding to questions of other students, posting your solutions to exercise problems prepared by the instructor) will be monitored closely.

Assignments

Homework assignments involve use of CAD tools for reconfigurable computing and application development for FPGAs.

Project, Term Paper, Presentation

Semester project will involve 2 phases:

- During the first half of the course, student will:
  - Propose a project on a selected topic taught in class,
  - Document their survey by reporting existing solutions,
  - Tackle a problem and propose their solution,
  - Present their initial findings and solution strategy
- During the second half of the course, student will:
  - Implement their proposed approach,
  - Put together a paper quality document with experimental results,
  - Present project findings

Accessibility and Accommodations: It is the University's goal that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, please let me know immediately so that we can discuss options. You are also welcome to contact Disability Resources (520-621-3268) to establish reasonable accommodations. Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

Absence and Class Participation Policy: The UA's policy concerning Class Attendance, Participation, and Administrative Drops is available at: http://catalog.arizona.edu/2015-16/policies/classatten.htm. The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, http://policy.arizona.edu/human-resources/religious-accommodation-policy. Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: http://uhap.web.arizona.edu/policy/appointed-personnel/7.04.02. Participating in course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all lectures and discussion section meetings. Students who miss class due to illness or emergency are required to bring documentation from their healthcare provider or other relevant, professional third parties. Failure to submit third-party documentation will result in unexcused absences.

General policies

- NO LATE ASSIGNMENTS WILL BE ACCEPTED, except under extreme non-academic circumstances discussed with the instructor at least one week before the assignment is due.
- **Make-ups** for assignments and exams *may* be arranged if a student's absence is caused by documented illness or personal emergency. A written explanation (including supporting documentation) must be submitted to your instructor; if the explanation is acceptable, an alternative to the graded activity will be arranged. When possible, make-up arrangements must be completed prior to the scheduled activity.
- Any extenuating circumstances that have an impact on your participation in the course should be discussed with your instructor as soon as those circumstances are known.
- Inquiries about graded material have to be turned in within 3 days of receiving a grade.
- Approximate weight of each reading and laboratory assignment will be specified when the assignment is handed out.
- Students are strongly encouraged to attend the class. Lecture notes are intended to serve as a supplement and not as a substitute for attending class.
- You are encouraged to discuss the assignment specifications with your instructor and your fellow students. However, anything you submit for grading must be unique and should NOT be a duplicate of another source. The Department of Electrical and Computer Engineering expects all students to adhere to UofA's policies and procedures on Code of Academic Integrity. http://web.arizona.edu/~studpubs/policies/cacaint.htm

Grading Scale and Policies: University policy regarding grades and grading systems is available at, http://catalog.arizona.edu/2015-16/policies/grade.htm

Distribution of Components		Grades Scale	
Component	**Percentage**	**Percentage**	**Grade**
Class Participation (Quiz)	15	85-100%	A
Assignments	20	70-84%	B
Exam	20	50-69%	C
Project (Presentation (10), Survey paper (10), Final paper and demonstration (25)	45	Below 50%	F

Exam Schedule:

Exam – March 13 (this tentative date may be postponed based on the class progress)
No final exam

Requests for incompletes (I) and withdrawal (W) must be made in accordance with University policies which are available at http://catalog.arizona.edu/2015-16/policies/grade.htm#I and http://catalog.arizona.edu/2015-16/policies/grade.htm#W respectively.

Honors Credit: Students wishing to contract this course for Honors Credit should email me to set up an appointment to discuss the terms of the contact and to sign the Honors Course Contract Request Form. The form is available at:
http://www.honors.arizona.edu/documents/students/ContractRequestFrom.pdf

Threatening Behavior Policy: The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to one's self. See: http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students.

Accessibility and Accommodations: Our goal in this classroom is that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, please let me know immediately so that we can discuss options. You are also welcome to contact Disability Resources (520-621-3268) to establish reasonable accommodations. For additional information on Disability Resources and reasonable accommodations, please visit http://drc.arizona.edu/**.**

If you have reasonable accommodations, please plan to meet with me by appointment or during office hours to discuss accommodations and how my course requirements and activities may impact your ability to fully participate.

Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

Code of Academic Integrity: Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity.

The University Libraries have some excellent tips for avoiding plagiarism available at: http://www.library.arizona.edu/help/tutorials/plagiarism/index.html.

UA Nondiscrimination and Anti-harassment Policy: The University is committed to creating and maintaining an environment free of discrimination, http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

Subject to Change Statement: Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.