ENGG3050: Reconfigurable Computing Systems
School of Engineering
University of Guelph
ENG3050
Winter 2010

Course Outline

Instructor

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Office Hours	Thur 10:00 - 12:00.

Lab Coordinator & Teaching Assistant

Lab Coordinator	Teaching Assistant
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Lecture & Lab Schedule

	Day	Time	Place
Lectures	Mon	11:30 - 12:30	MACK 308
	Wed	11:30 - 12:30	MACK 308
	Fri	11:30 - 12:30	MACK 308
Laboratory	Thu	8:30 - 10:30	Thorn 2307

Text Books & References

1. "Reconfigurable Computing: The Theory and Practice of FPGA-Based Computing", Edited by S. Hauck and A. Dehon, Morgan Kaufmann, 2008, ISBN 978-0-12-370522.

2. "Introduction to Reconfigurable Computing: Architectures, Algorithms and Applications", by C. Bobda Springer, 2008, ISBN 978-1-4020-6088-5.

3. "Reconfigurable Computing: Accelerating Computation with FPGAs", by M. Gokhale and P. Graham, Springer, 2005, ISBN 0-387-26105-2.

4. "FPGA-Based System Design", by Wayne Wolf, Prentice Hall, 2004, ISBN 0-13-142461-0.

5. "Computer Organization and Design", by D. Patterson and J. Hennessey, Morgan Kaufmann, 2005, ISBN 1-55860-604-1

6. "VHDL", 3rd Edition, by Douglas Perry, McGraw Hill, 1998, ISBN 0-07-049436-3.

7. "The Designer's Guide to VHDL", by Peter Ashenden, Morgan Kaufmann, 2002, ISBN 1-55860-674-2.

Course Contents, Goals and Objectives:

Reconfigurable Computing Systems (RCS) refers to a new class of computer architecture which take advantage of application level-parallelism. This course deals mainly with digital systems implemented on Field Programmable Gate Arrays (FPGA). In this course, we investigate the state-of-the-art in reconfigurable computing and the main factors driving it. Initially, we review the basic concepts of programmable logic in general and FPGA's in particular. Design entry based on Hardware Descriptive Languages and High Level Languages will also be covered. Specific reconfigurable computing systems (i.e architectures) will be examined with emphasis on limitations and future research opportunities. The main objectives of the course are:

- Understand the basic concept of Reconfigurable Computing both from a hardware and software perspective.
- Teach students about digital hardware, its specification, design and implementation.
- Acquaint students with both low level hardware description languages (HDL) and state of the art high level languages such as System-C and Handel-C.
- Implement a complete digital system on FPGA's using state-of-the art CAD tools.
- Use different analysis and verification tools, implementation and synthesis methodologies and testability techniques that will enable them to design high performance and efficient digital systems.

Students taking this course will communicate their basic understanding of digital design and computer architecture through a project where they apply some or all of the techniques they learned in designing a complete reconfigurable system.

Reason for Course Offering:

The electronics industry has achieved a phenomenal growth over the last few decades, mainly due to the rapid advances in integration technologies and large-scale systems design. The use of integrated circuits in high-performance computing, telecommunications, and consumer electronics has been growing at a very fast pace. Typically, the required computational and information processing power of these applications is the driving force for the fast development of this field. The objective of this course is to help students develop in-depth analytical and design capabilities in digital circuit and chips. Thus, the ability to understand, analyze and design such systems has become an indispensable skill that engineers must have. With this skill they will be able to acquire more sustainable employment and help Canada become an even stronger competitor in the global marketplace, which is undergoing a fundamental transformation to knowledge-based industries. The proposed course seeks to provide the students with strong hardware design fundamentals suitable for employment with computer-design companies. It will serve to provide the groundwork that the students require in the digital systems area. The project and assignments will give the students genuine design experience, introducing them to the use of CAD tools for circuit design and full custom layout.

Learning Outcomes

By the end of this course, students should:

- Understand the basic concepts of Reconfigurable Computing Systems and its usage in developing complete digital systems.
- Be familiar with several CAD tools used in VLSI design such as Xilinx ISE Foundation, Celoxica Handel-C and Tensilica Tools.
- Design digital systems for a variety of applications, including microcomputers and special purpose computing systems.
- Be able to design high performance digital systems with operating speed in the multiple hundreds of MHZ.

Prerequisites (Required Skills):

1. Knowledge in digital design and computer architecture is essential.
2. Basic Knowledge of programming languages (i.e C, C++) is essential.
3. Experience in transistor theory and VLSI Design may be helpful in understanding some of the course material but are not required.

Main Topics To Be Covered:

- Programmable Logic Devices (i.e., PLDs and FPGAs).
- Hardware Description Languages (i.e., VHDL).
- CAD for Programmable Logic Devices.
- Electronic System Level (ESL, System-C, Handel-C).
- Application Specific Instruction Processors (ASIPs).
- Reconfigurable Processors/Accelerators.
- Issues in Hardware/Software Co-design.

Tentative Course Outline:

Week	Date	Topic
1	Jan 11-Jan 15	Introduction to Reconfigurable Computing
2	Jan 18-Jan 22	Programmable Logic Devices (FPGAs, CPLDs)
3	Jan 25-Jan 29	Hardware Descriptive Languages (VHDL)
4	Feb 01-Feb 05	Hardware Descriptive Languages (VHDL)
5	Feb 08-Feb 12	CAD For FPGA (Placement, Routing, Synthesis)
6	Feb 15-Feb 19	**Spring Break**
7	Feb 22-Feb 26	Electronic System Level (ESL i.e., Handel-C)
8	Mar 01-Mar 05	Hardware/Software Co-Design & RTR
9	Mar 08-Mar 12	*Paper Review I*
10	Mar 15-Mar 19	Application Specific Instruction Processors
11	Mar 22-Mar 26	Reconfigurable Processors & Signal Processing
12	Mar 29-Apr 02	Reconfigurable Applications
13	Apr 05-Apr 09	*Paper Review II*

Resources

The students are expected to design a hardware system using a hardware descriptive language (i.e VHDL or Handel-C). The possible resources that are available and others that are needed are summarized.

- Xilinx Foundation Tools.
- Celoxica DK Suit.
- Matlab & Xilinx AccelDSP.
- Mentor Graphics Simulation Tools.
- Tensilica XPRESS and TIE Tools.

Evaluation

Topic	Weight	Details
Paper Review	10 %	30-45 minutes
Lab & Assignments	30 %	3 Assignments
Project Report	30 %	see instructor
Final Exam	30 %	Closed Book Exam

Paper Review

Besides the assignments, each student is assigned a journal article to read. The student must prepare a brief (about 30-45 minutes) oral description of the article, its objectives, methods, results and contributions to present to the class. A two page summary (detailed) giving the citation and the material in the oral presentation must be written and a copy is distributed to each class member.

The articles are selected so that they pertain to current or very recent classroom material. **Several topics and related literature are found on the course web-page**. Here are some general points to consider when reading about a particular study:

- What is the general purpose of the article, who it is intended for, and why is the topic important.
- What are the main results.
- Indicate the technique used and the experimental methodology followed. Was the analysis sufficient?
- What do you think is the main contribution of the article? How is work unique? Who might benefit from the results? Practitioners, researchers, managers, etc?
- What are the weaknesses and strengths of the work? How might it have been improved? What are your recommendations for future work in this area.

The following are some conferences and journals that you can get articles from:

- ACM/IEEE Conference on Field Programmable Gate Arrays.
- IEEE Transactions on Computers.
- IEEE Conference on Systems Man, and Cybernetics.
- IEEE Transaction on Computer Aided Design.
- International Conference on Computer Aided Design.
- Design Automation Conference.

Research Project

Each of you will select a topic related to FPGA/RCS design. You should conduct an in-depth study covering the problem to be solved and its origins, developments, and current status. This will involve extensive research; your findings should be documented in a report with the basic references cited. Background reading should include several articles. In writing your report you should think about what you have read, and provide your personal opinions about the presentation and usefulness of the work. **Sample projects could be found on the course web-page**.

Communication

Communication is through (i) Email, (ii) Web page.

Academic Misconduct

The policy for this course is zero tolerance for any form of academic misconduct. Consultation with other students is encouraged especially on design issues. However, directly copying another student's work or copying portions of written work that are taken word-for-word from other authors (researchers) is an honour code violation and will result in a failing grade and may result in a failing grade in the course. **Please refer to the regulations outlined in the student handbook regarding academic misconduct.**