ACADEMIC-GRADUATE STUDIES AND RESEARCH DIVISION

FIRST SEMESTER 2022 - 2023

COURSE HANDOUT (PART II)

Date: 12 / 08 / 2023

In addition to Part I (General Handout for all courses appended to the timetable) this portion gives further specific details regarding the course.

Course No : CS G553
Course Title : Reconfigurable Computing
Instructors/in-charge : Subhendu Kumar Sahoo

1.Course Description: Overview of Programmable Logics. FPGA fabric architectures. Logic Elements and Switch Networks. Design and Synthesis of Combinational and Sequential Elements. Placement and Routing. Pipelining and other Design Methodologies. Fine-grained and Coarse-Grained FPGAs. Static and Dynamic Reconfiguration. Partitioning. Hardware/Software Portioning and Partial Evaluation. Systolic Architectures.

2.Scope and Objective

Reconfigurable (adaptive) computing is a novel yet important research field investigating the capability of hardware to adapt to changing computational requirements such as emerging standards, late design changes, and even to changing processing requirements arising at run-time. Reconfigurable computing thus benefits from a) the programmability of software similar to the Von Neumann computer and b) the speed and efficiency of parallel hardware execution.
The purpose of the course reconfigurable computing is to instruct students about the possibilities and rapidly growing interest in adaptive hardware and corresponding design techniques by providing them the necessary knowledge for understanding and designing reconfigurable hardware systems and studying applications benefiting from dynamic hardware reconfiguration.

3.Contents

The course covers the following subjects:

- Reconfigurable computing systems (Fine and coarse-grained architectures and technology)
- Design and implementation (Algorithms and steps to implement algorithms to FPGAs)
- Temporal partitioning (Techniques to reconfigure systems over time)
- Temporal placement (Techniques and algorithms to exploit the possibility of partial and dynamic hardware reconfiguration)
- On-line communication (State-of-the-art techniques about how modules can communicate data at run-time)
- Applications (applications benefiting from dynamic hardware reconfiguration and verification using Xilinx System Design tools and Boards).

4.Background

Basic knowledge in the following areas: digital design, optimization algorithms, and computer architecture.

5.Textbook

1. C Bobda, Introduction to Reconfigurable Computing: Architectures, Algorithms, and Applications, Springer, 2007.
2. Wolf Wayne, *FPGA Based System Design*, Pearson Edu, 2004.

Reference Book

1. Scott Hauck, André DeHon, Reconfigurable Computing - The Theory and Practice of FPGA Based Computation, The Morgan Kaufmann Series in Systems on Silicon, 2007.
2. R Vaidyanathan, Trahan Jerry, Dynamic Reconfiguration: Architectures and Algorithms, L, Kluwer Academic, 2003.
3. Uwe Meyer-Baese, DSP with FPGAs, Springer-Verlag, 2003.
4. Journal papers and Conference publications (will be uploaded in the course website)Course Plan

6.COURSE PLAN

Lecture No.	Learning Objectives	Topics to be covered
01 - 02	Introduction	Introduction application and comparison • General Purpose Computing • Domain Specific Computing • Application Specific Computing • Reconfigurable Computing
03 - 04	VLSI Technology	Wires, Registers and RAM (self study assignment) • Wires and vias • Gate delay vs. wire delay • Registers and RAM
05 - 06	Reconfigurable Computing Hardware	Programmable logic, an overview of • PLA, PAL, SPLD and CPLD
07 - 08	Hardware Description Languages and Logic Design	Modeling with HDLs (self study assignment) • Verilog/VHDL Combinational Network Delay, Power and Energy Optimization
09 - 12	Reconfigurable Computing Device	FPGA Architecture, FPGA Fabrics Configuration • SRAM Based-FPGAs • Permanently Programmed FPGAs Programmable I/O, Circuit Design of FPGA Fabrics, Architecture of FPGA Fabrics, Case Studies (Xilinx, Altera, Microsemi etc).
13 - 14	Reconfigurable Computing Architecture	Fine - Grained and Course - Grained Reconfigurable Architecture, Case Studies.
15 - 17	Programming Reconfigurable Systems	Logic Design Process • Design • Integration • FPGA Design Flow Implementation Approaches • Run Time Reconfiguration (RTR) • Partial Reconfiguration (PR)
18 - 21	Mapping Designs to Reconfigurable Platform	Logic Implementation for FPGAs, Syntax-Directed Translation Logic Synthesis • Two-Level Logic Synthesis • Multi-Level Logic Synthesis LUT-Based Technology Mapping
22 - 27	High-Level Synthesis for Reconfigurable Devices (Behavioral Design)	Modeling • DFG, CFG Introduction to Binding, Scheduling and Allocation, Temporal Partitioning Temporal Partitioning Algorithms • ASAP • ALAP
28 - 30	Temporal Placement and Routing	Offline and Online Temporal Placement Routing Cost, Routing-Conscious Placement
31 - 33	Online Communication	Communication at run-time between modules on the Reconfigurable Device
34 - 35	Reconfiguration Management	Multi-Context FPGAs, Introduction to Partial Reconfiguration
36 - 37	Security in Modern Reconfigurable Devices	Protecting the FPGA design from common threats, Design security concerns, Secure architecture in FPGAs and SoC FPGAs.
38 - 40	Applications and Example Case Studies	Image Processing, Signal Processing, Pattern Matching, etc..

7.Evaluation Scheme

EC No.	Evaluation Component	Duration (min)	Weightage (%)	Date & Time	Nature of Component
1.	MID SEM EXAMINATION	90	25	10/10 11.30 - 1.00PM	Closed Book
2.	Lab Assignment/ Lab test/Project and Viva	---------	10+10+20	Will be announced	Open Book
3.	Comprehensive	180	35	09/12/23 (AN)	Closed Book

8.Lab

This course has lab components using Xilinx Vivado design suite. Final design should be implemented in Xilinx FPGAs.

9.Chamber Consultation Hours

Will be announced in the class

10.Notices

Notices regarding the course will be put up on the course web site (Google classroom)

11.Makeup

Make-up will be given on **genuine** grounds only. Prior application should be made for seeking the make- up examination.

12. Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Instructor - in - charge
CS G553