Workshop Title: Introduction to Using FPGAs in the Computer Science Curriculum

Presenters:

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Abstract: One of the challenges in modern curriculum design is balancing between breadth and depth of topics while simultaneously reinforcing the interconnections among topics in the field. To address these challenges, faculty are often forced to approximate real-world systems, sometimes at the expense of any hands-on experience. We have integrated field-programming gate array (FPGA) systems first used in our hardware-based courses into several higher-level systems and applications courses. This allows us to leverage student familiarity with a hands-on, flexible hardware platform and also strengthen the relationships between different subfields within computer science. In this workshop, we present participants with guided hands-on activities for making use of FPGAs in common computer science courses such as digital logic design, computer organization and assembly programming, and compiler construction. Laptop required to run software and demos; however, if the participant wishes to work with a partner or simply observe, the laptop is not necessary.

Intended audience: Undergraduate CS educators who are responsible for teaching and/or coordinating such courses as: operating systems, digital logic design, computer organization and architecture, compiler implementation, and other systems-oriented classes.

Presenter Biographies:
William M. Jones is an Assistant Professor in the Computer Science Department at Coastal Carolina University. He has a academic background in electrical and computer engineering with a research focus on parallel and distributed computing. While working at the United States Naval Academy, he began exploring the use of FPGAs as a valuable platform for teaching digital logic design and computer architecture. After moving to Coastal Carolina University, he expanded this use to courses involving assembly programming as well. His paper presentation, “Integrating Digital Logic Design and Assembly Programming Using FPGAs in the Classroom” at the 2011 ACM Southeast Regional conference was well received and is the foundation for two of the four sections of this workshop.

D. Brian Larkins is an Assistant Professor in the Computer Science Department at Coastal Carolina University. His research background is in parallel programming models and distributed systems. He has been working with the Altera FPGA systems as a teaching tool at Coastal Carolina, integrating them into compiler implementation and image processing classes. Prior to academia, Dr. Larkins accumulated over 10 years of experience in industry. His prior work includes leading very large-scale network design and Internet security projects with AT&T Bell Laboratories. He has also worked for three startup firms, which entailed developing both an image processing and video streaming appliance, as well as a machine-learning system which performed network intrusion detection.

Each presenter has previously taught courses that make use of FPGAs in multiple areas within the computer science curriculum.

Materials provided: Each participant receives an electronic copy of (1) detailed handouts to be used during the lecture portions of the workshop, (2) all software necessary, (3) selected project assignments and solutions. Additionally, 15 FPGA platforms will be available for participants to use; however, these devices must be returned to the presenters at the conclusion of the workshop.
Rough Agenda: (subject to change, item 5 may be skipped depending on remaining time)

1. Introduction to FPGAs (approximately 20 minutes)
   - Overview of FPGA terminology and capability / software installation
2. Digital Logic Design Example (approximately 30 mins)
   - Project initialization in IDE and use of schematic capture input
   - Synthesize hardware and map to I/O on FPGA
3. Assembly Programing Example on NIOS II Soft Processor (approximately 40 mins)
   - Use of SOPC builder to instantiate NIOS II processor
   - Modify given assembly program to illustrate salient concepts
   - Compile and run user program directly on FPGA
   (break, approximately 10 mins)
4. Compiler Implementation Example (approximately 40 mins)
   - Overview of the Tiger compiler project
   - Hardware configuration of on-chip and on-board components
   - Compiler run-time support and execution of a Tiger program on the FPGA
5. Running Linux on the FPGA (approximately 30 mins)
   - Overview of the processor and associated peripheral devices
   - Overview of uLinux OS / load and boot uLinux on FPGA
6. Workshop Wrap-up BOF (approximately 10 mins)
   - Discuss possible integration of FPGAs at participant institutions
   - Discuss additional courses where FPGAs fit well

Audio/Visual and Computer requirements: All participants must have a laptop and ideally would have wireless internet access. We will also need a digital projector (for presenters) Windows, Mac, and Linux laptops will be supported. FPGA software is designed for Windows and is the preferred host OS. OSX and Linux will be supported via virtual machine installs.

Laptop Required: All participants will need a laptop for running the FPGA IDE and associated software. Instructions for installing this freely available software will be provided in advance to those participants that register early. Additionally, this software will also be available on the day of the workshop. If participant wishes to simply work with a partner or observe, laptop would not be necessary.

Space and Enrollment restrictions: Enrollment must be limited to 15, as we will have only have access to 15 individual FPGA hardware platforms. Each participant will have access to a complete FPGA system to utilize in following along and completing the workshop exercises. Additionally, each seat must have access to two 120 V AC electrical sockets for powering the FPGA platforms and potentially participant laptops. Note, we could support 30 participants with the given hardware using groups of two, which would be reasonable given the scope of the content. Guidance from proposal reviewers would be particularly welcomed here.

Other critical information: A previous version of this workshop was run locally at Coastal Carolina University and presented to other CS and IS faculty. Additionally, presentations regarding FPGA integration in the classroom have been given at the 2011 ACM Southeast Regional conference, the 2009 and 2010 Myrtle Beach Computer Security Conference, and the 2011 Grand Strand Technology Expo. The content of this workshop is based upon our experiences using FPGAs in the classroom, as well as from feedback we have received at the mentioned venues. We expect this to be a valuable experience for SIGCSE participants.