# Introduction to the Special Section on FCCM'16

The International Symposium on Field-Programmable Custom Computing Machines (FCCM) is the original and premier forum for presenting and discussing new research related to computing that exploits the unique features and capabilities of field programmable gate arrays (FPGAs) and other reconfigurable hardware. Since its first meeting in 1993, FCCM has been the place to present the latest work in architectures, tools, and programming models for field-programmable custom computing machines as well as applications that use such systems. The 24th FCCM met May 1 to 3, 2016 near Washington, DC in Old Town Alexandria, Virginia.

In this special *ACM TRETS* section, it is our pleasure to present extended versions of a selected set of three of the 31 papers accepted and presented at FCCM '16. These three articles address three significant challenges for modern reconfigurable computing: online power estimation for FPGA-based system-on-chip (SoC) designs, self-monitoring and repair of FPGA devices to compensate for aging and environmental effects, and improving performance for soft processors by way of out-of-order superscalar instruction scheduling. We summarize the research contributions and highlights of each article below.

FPGA vendor tools can estimate a design's power consumption at compile-time, and platform vendors often provide a way to monitor an FPGA's power consumption. However, neither of these methods allow a designer to accurately measure online power consumption for individual modules within an SoC design under changing operating conditions. In "KAPow: High-Accuracy, Low-Overhead Online Per-Module Power Estimation for FPGA Designs" (the recipient of FCCM'16's best paper award), the authors describe an automated tool that identifies and instruments signals having high dynamic power consumption within a placed-and-routed netlist. The authors employ an online system identification model using the recursive least squares algorithm to maintain a linear model against running observed measurements, achieving accuracy to within 5 mW.

Vendor-supplied timing analysis tools always assume worst-case conditions to account for aging and environmental factors (temperature, supply voltage). This often forces designs to run significantly slower than their highest stable clock rate for their current condition. The authors of "Continuous Online Self-Monitoring Introspection Circuitry for Timing Repair by Incremental Partial-Reconfiguration (COSMIC TRIP)" developed a method to continuously monitor deployed FPGA designs that continuously measure timing between LUT pairs, identifies paths with slack violations, and, within milliseconds, repairs failed paths through reassignment to precomputed alternative tracks. This work builds on the authors' earlier work in "Choose-Your-Own-Adventure Routing."

Using softcore processors significantly reduces design effort when building large FPGA systems, but all commercial softcore processors suffer from limited performance owing to being in-order, single-issue architectures. The authors of "High-Performance Instruction Scheduling Circuits for Superscalar Out-of-Order Soft Processors" evaluated the design space of instruction schedulers for an x86 softcore processor. Each x86 instruction is decomposed into up to four types of micro-operations (load, branch, integer arithmetic, store), which lends itself to a distributed scheduler design in which a scheduler is attached to each execution unit. The authors experimentally evaluated design decisions to solve the two primary challenges of instruction scheduling: (1) wake up


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and selection logic, for which they use a matrix-based design; and (2) instruction age tracking, for which they use a compaction-based design. Their multi-issue design achieved a clock speed comparable to that of a commercial single-issue processor.

As guest editor, I would like to thank the authors for submitting and presenting high-quality articles as well as the anonymous reviewers for their reviews and important suggestions for improving previous versions of the papers presented here. I would also like to acknowledge support of the FCCM'16 General Chair Matthew French (of Information Sciences Institute) and Steve Wilton (*ACM TRETS* editor-in-chief), Philip Leong (*ACM TRETS* senior associate editor), and Kyle Rupnow (*ACM TRETS* information director).

It is my hope that you enjoy reading the articles included in this special section and that they serve as useful sources of research inspiration,

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