Int J Parallel Prog (2009) 37:343–344
DOI 10.1007/s10766-009-0112-y

EDITORIAL

Guest Editor Introduction: Special Issue on Nano/Bio-Inspired Applications and Architectures

Prabhat Mishra

Received: 1 June 2009 / Accepted: 7 June 2009 / Published online: 16 June 2009

The field of computing today is faced with a major challenge—how to efficiently design and implement computing systems to solve tomorrow's complex problems? Architects recognize that biology is a valuable source of inspiration for efficiently solving many complex problems in architecture, networks, and nanoscale systems. Designers also recognize the importance of nanotechnology for efficient implementation of computing systems. Recent trends suggest a significant shift in research focus towards biologically inspired computing and nanotechnology. This special issue contains four excellent papers on the topics related to nano/bio-inspired applications and architectures.

The first two papers address the challenges associated with modeling and validation of complex biological systems. In the first paper, "Brain Derived Vision Algorithm on High Performance Architectures", Nageswaran et al. exploit the features of modern microprocessors to efficiently model and implement massively parallel brain systems. This paper describes the details of a brain derived vision algorithm that is derived from the anatomical structure, and physiological operating principles of thalamo-cortical brain circuits. The authors show that many characteristics of the algorithm lend themselves to implementation on IBM CELL architecture, and yield significant speedups that equal or exceed the performance of specialized solutions such as FPGAs, and thus enabling real-time object recognition for robotic systems.

In the second paper, "On-Line Testing of Lab-on-Chip Using Reconfigurable Digital-Microfluidic Compactors", Zhao and Chakrabarty present an online-testing method to improve dependability of microfluidic lab-on-chip devices. Dependability is an essential system attribute for such devices since they are expected to be deployed

P. Mishra (✉)
Computer and Information Science and Engineering, University of Florida,
Gainesville, FL 32611, USA
e-mail: prabhat@cise.ufl.edu

for safety-critical biomedical applications as well as environmental and food toxicity monitoring. This paper presents a built-in self-test method that utilizes microfluidic compactors based on droplet-based "and" gates, which are implemented using digital microfluidics. The authors propose an optimization method to schedule logic "and" operations in the compactor to minimize the end time for the compaction procedure. Dynamic reconfiguration of these compactors ensures low area overhead and it allows built-in self-test to be interleaved with bioassays in functional mode.

The next two papers address the challenges associated with design, estimation and evaluation of nano-inspired architectures. In the third paper, "Design and Evaluation of a Carbon Nanotube-Based Programmable Architecture", Chilstedt et al. propose a carbon nanotube based FPGA architecture called FPCNA. The authors describe the building blocks of FPCNA as well as a high-density routing architecture. To accurately determine the performance of these building blocks, the authors create variation-aware physical design tools with statistical timing analysis that can handle both Gaussian and non-Gaussian random variables. The paper demonstrates that FPCNA delivers both significant performance improvement over an equivalent CMOS FPGA at a 95% yield and drastic footprint reduction compared to the baseline FPGA.

In the fourth paper, "New-Age: A NBTI-Estimation Framework for Microarchitectural Components", DeBole et al. introduce a comprehensive approach to high-level aging estimation to enable the reliability assessment of a microarchitecture and to provide an indication of its lifetime in the presence of negative bias temperature instability. The paper describes a framework that includes workload-based temperature and performance degradation analysis across a variety of technologies and operating conditions, revealing a complex interplay between factors influencing NBTI timing degradation. The authors demonstrate the usefulness of the framework by evaluating the lifetime of two designs— sub-components found within arithmetic logic units, and pipeline stages of an out-of-order superscalar processor.

There is a lot more to learn in this area including efficient modeling and evaluation methods, novel prototyping and implementation techniques, architectural considerations, verification and test, parallel algorithms, and case studies. I hope that the four papers in this special issue will provide interesting and useful concepts to readers, and it will also motivate readers to pursue further research in nano/bio-inspired applications and architectures.