J Supercomput
DOI 10.1007/s11227-010-0485-0

Energy-efficient high-performance parallel and distributed computing

Samee Ullah Khan · Pascal Bouvry · Thomas Engel

1 Introduction

High-Performance Computing (HPC) is a major contributor to cutting-edge research and discovery in science and technology. We can attribute several key research findings that were aided or validated by tests and simulations run on HPCs. Over the last decade, we have witnessed computing service providers to continually upgrade their infrastructures to HPCs that can meet the increasing demands of powerful newer applications. In parallel, almost in concert, computing manufacturers have consolidated and moved from stand-alone servers to rack mounted blades. The aforementioned trends alone are increasing electricity usage in large-scale computing systems, such as data centers, computational grids, and cloud computing. This increase in electricity utilization has reached to a point that many information technology managers are all up in arms to identify a holistic solution that can reduce electricity consumption (so that the total cost of operation is minimized) of their respective large-scale computing systems and simultaneously improve upon or maintain the current throughput of the system.

S.U. Khan
NDSU-CIIT Green Computing and Communications Laboratory, Electrical and Computer Engineering Department, North Dakota State University, Fargo, ND 58108-6050, USA
e-mail: samee.khan@ndsu.edu

P. Bouvry (✉) · T. Engel
Faculty of Sciences, Technology and Communications, CSC&SnT, University of Luxembourg, Luxembourg, Luxembourg
e-mail: pascal.bouvry@uni.lu

T. Engel
e-mail: thomas.engel@uni.lu

Published online: 12 October 2010

2 Research problems in energy-efficient HPCs

We must understand that in HPCs the energy efficiency must not come at the expense of performance. Therefore, innovative methodologies must be conceived that can balance energy consumption and performance. The key research issue remains in providing a holist solution that can collectively minimize energy consumption of a HPC facility. Researchers have fundamentally focused in isolation on improving energy consumption of the: (a) optimizing the room cooling system, (b) processing elements by scheduling and mapping, (c) network by intelligent routing, and (d) memory by reducing data migration. Because performance and energy consumption must be balanced in a HPC environment, solutions that salvage energy at all of the three computing components must be considered. This is a difficult task because the complexity of the meta model to capture such interactions will increase astronomically. This also is the reason why we consider such an approach a key research issue in Energy-efficient HPCs.

3 Selected papers for the Special Issue

Several high quality research articles were submitted. We (the guest editors) had a very difficult decision to make on the inclusion and exclusion of research articles. Because of the space constraints, we could only include the following five outstanding research articles.

"Proactive Thermal Management in Green Datacenters" proposes an intelligent temperature regulating mechanism for data centers.

"Improving Performance and Energy Efficiency of Embedded Processors via Post-Fabrication Instruction Set Customization" introduces an adaptive extensible processor in which custom instructions are generated and added after chip-fabrication to reduce energy consumption and improve performance.

"Energy Efficient Scheduling of Parallel Tasks on Multiprocessor Computers" proposes a methodology to schedule parallel tasks on multiprocessors using dynamic voltage and speed scaling.

"Reliability-Aware Platform Optimization for 3D Chip Multiprocessors" proposes an optimization methodology that integrates power, performance, and temperature for multiprocessor systems.

"Energy Efficient Utilization of Resources in Cloud Computing Systems" introduces a task consolidating technique to mitigate energy consumption in under utilized large-scale computing systems.

Acknowledgements The guest editors are in debt and give thanks to the knowledgeable reviewers that delivered timely assessments on the research articles submitted to this special issue.

We acknowledge funding from Luxembourg FNR GreenIT project (C09/IS/05).