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Simon Devitt · Ivan Lanese (Eds.)

Reversible Computation

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Preface

This volume contains the papers presented at RC 2016, the 8th Conference on Reversible Computation, held during July 7–8, 2016, in Bologna (Italy), hosted by the Computer Science Department of the University of Bologna.

The Conference on Reversible Computation brings together researchers from computer science, mathematics, engineering, and physics to discuss new developments and directions for future research in the emerging area of reversible computation. This includes, e.g., reversible formal models, reversible programming languages, reversible circuits, and quantum computing.

The conference received 38 submissions by authors from 22 countries. All papers were reviewed by at least three members of the Program Committee. After careful deliberations, the Program Committee selected 23 papers for presentation. In addition to these papers, this volume contains the abstracts of the two invited talks: "DEMONIC Programming: A Computational Language for Single-Particle Equilibrium Thermodynamics, and Its Formal Semantics" by Samson Abramsky (University of Oxford, UK) and "Classical Problems to Make Quantum Computing a Reality" by Adam Whiteside (University of Melbourne, Australia and Google).

The conference would not have been possible without the enthusiasm of the members of the Program Committee; their professionalism and their helpfulness were exemplary. For the work of the Program Committee and the compilation of the proceedings, the EasyChair system was employed, which was extermely useful. Finally, we would like to thank all the authors for their submissions, their willingness to continue improving their papers, and their presentations!

April 2016

Ivan Lanese
Simon Devitt

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Abstracts of Invited Talks

Classical Problems to Make Quantum Computing a Reality

Adam C. Whiteside[1,2], Austin G. Fowler[2,1]

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(Dated: April 15, 2016)

Recent experiments have shown exciting progress toward creating reliable quantum bits (qubits) that will make up tomorrow's quantum computers. While experiments and engineers continue to make the physical side a reality, computer scientists and software engineers will be essential to getting the most out of such expensive hardware. An entire stack of classical software must be developed, requiring creative solutions to a broad range of problems. We provide an introduction to quantum computing and an overview of the problems left to face in an effort to inspire more research in these important areas.

DEMONIC Programming: A Computational Language for Single-particle Equilibrium Thermodynamics, and its Formal Semantics

Samson Abramsky[1] and Dominic Horsman[2]

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Abstract. Maxwell's Demon, 'a being whose faculties are so sharpened that he can follow every molecule in its course', has been the centre of much debate about his abilities to violate the second law of thermodynamics. Landauer's hypothesis, that the Demon must erase its memory and incur a thermodynamic cost, has become the standard response to Maxwell's dilemma, and its implications for the thermodynamics of computation reach into many areas of quantum and classical computing. It remains, however, still a hypothesis.

Debate over the existence of an erasure cost for information has often centred around simple toy models of a single particle in a box. Despite their simplicity, the ability of these systems to accurately represent thermodynamics (specifically to satisfy the second law) and whether or not they display Landauer Erasure, has been a matter of ongoing argument. The recent Norton-Ladyman controversy is one such example.

In this paper we give a computational language for formal reasoning about thermodynamic systems. We formalise the basic single-particle operations as statements in the language, and then show that the second law must be satisfied by any composition of these basic operations. This is done by finding a computational invariant of the system. We show, furthermore, that this invariant requires an erasure cost to exist within the system, equal to $kT \ln 2$ for a bit of information: Landauer Erasure becomes a theorem of the formal system. The Norton-Ladyman controversy can therefore be resolved in a rigorous fashion, and moreover the formalism we introduce gives a set of reasoning tools for further analysis of Landauer erasure, which are provably consistent with the second law of thermodynamics.

Contents

Syntheses