Lusheng Wang (Ed.)

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# Computing and Combinatorics

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# Computing and Combinatorics

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# Preface

The papers in this volume were presented at the *Eleventh Annual International Computing and Combinatorics Conference* (COCOON 2005), held August 16–19, 2005, in Kunming, China. The topics cover most aspects of theoretical computer science and combinatorics related to computing.

Submissions to the conference this year were conducted electronically. A total of 353 papers were submitted, of which 96 were accepted. So the competition is very fierce. The papers were evaluated by an international program committee consisting of Tatsuya Akutsu, Vineet Bafna, Zhi-Zhong Chen, Siu-Wing Cheng, Francis Chin, Sunghee Choi, Bhaskar DasGupta, Qizhi Fang, Martin Farach-Colton, Raffaele Giancarlo, Mordecai Golin, Peter Hammer, Tsan-sheng Hsu, Sorin C. Istrail, Samir Khuller, Michael A. Langston, Jianping Li, Weifa Liang, Guohui Lin, Bernard Mans, Satoru Miyano, C. K. Poon, R. Ravi, David Sankoff, Shang-Hua Teng, H. F. Ting, Seinosuke Toda, Takeshi Tokuyama, Peng-Jun Wan, Lusheng Wang, Todd Wareham, Jinhui Xu, Xizhong Zheng, Kaizhong Zhang and Binhai Zhu.

The authors of submitted papers came from more than 25 countries and regions. In addition to the selected papers, the conference also included three invited presentations by Alberto Apostolico, Shang-Hua Teng, and Leslie G. Valiant. This year's Wang Hao Award (for young researchers) was given to the paper *Approximating the Longest Cycle Problem on Graphs with Bounded Degree* by Guantao Chen, Zhicheng Gao, Xingxing Yu and Wenan Zang.

I would like to thank all the people who made this meeting possible and enjoyable: the authors for submitting papers and the program committee members and external referees for their excellent work. I would also like to thank the three invited speakers and the local organizers and colleagues for their assistance.

August 2005 Lusheng Wang

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# Completeness for Parity Problems*

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**Abstract.** In this talk we shall review recent work on holographic algorithms and circuits. This work can be interpreted as offering formulations of the question of whether computations within such complexity classes as NP, $\oplus$P, BQP, or #P, can be efficiently computed classically using linear algebra. The central part of the theory is the consideration of gadgets that map simple combinatorial constraints into gates, assemblies of which can be evaluated efficiently using linear algebra. The combinatorial constraints that appear most fruitful to investigate are the simplest ones that correspond to problems complete in these complexity classes. With this motivation we shall in this note consider the parity class $\oplus$P for which our understanding of complete problems is particularly limited. For example, among the numerous search problems for which the existence of solutions can be determined in P and the counting problem is known to be #P-complete, the #P-completeness proof does not generally translate to a $\oplus$P-completeness proof. We observe that in one case it does, and enumerate several natural problems for which the complexity of parity is currently unresolved. We go on to consider two examples of NP-complete problems for which $\oplus$P-completeness can be proved but is not immediate: Hamiltonian circuits for planar degree three graphs, and satisfiability of read-twice Boolean formulae.

## 1 Introduction

The class $\oplus$P is the class of sets S such that there is a polynomial time nondeterministic Turing machine that on input $x \in S$ has an odd number of accepting computations, and on input x $\notin S$ has an even number of accepting computations ([V79], [PZ83], [GP86]). It formalizes the question of the parity of the number of solutions to combinatorial problems. It is known that $\oplus$P has at least the computational power of NP, since NP is reducible to $\oplus$P via (one-sided) randomized reduction [VV86]. Also, the polynomial hierarchy is reducible to it via two sided randomized reductions [TO92]. The class FewP of sets for which there exist NP machines with few accepting computations is a subclass of it [CH90]. Further, there exist decision problems, such as graph isomorphism, that are not known to be in P but are known to be in $\oplus$P [AK02]. The class $\oplus$P has been related to other complexity classes via relativization [BBF98].

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