Michele Bugliesi
Bart Preneel
Vladimiro Sassone
Ingo Wegener (Eds.)

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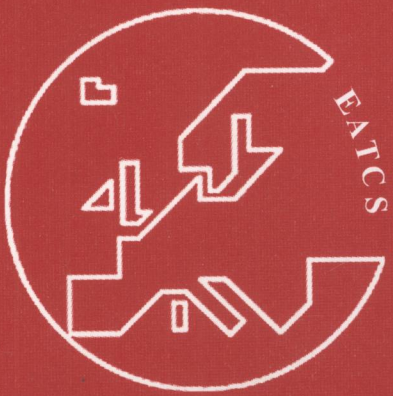
Automata, Languages and Programming

33rd International Colloquium, ICALP 2006
Venice, Italy, July 2006
Proceedings, Part II

2 Part II



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Automata, Languages and Programming

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Venice, Italy, July 10-14, 2006
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Preface

ICALP 2006, the 33rd edition of the International Colloquium on Automata, Languages and Programming, was held in Venice, Italy, July 10–14, 2006. ICALP is a series of annual conferences of the European Association for Theoretical Computer Science (EATCS) which first took place in 1972. This year, the ICALP program consisted of the established track A (focusing on algorithms, automata, complexity and games) and track B (focusing on logic, semantics and theory of programming), and of the recently introduced track C (focusing on security and cryptography foundation).

In response to the call for papers, the Program Committee received 407 submissions, 230 for track A, 96 for track B and 81 for track C. Out of these, 109 papers were selected for inclusion in the scientific program: 61 papers for Track A, 24 for Track B and 24 for Track C. The selection was made by the Program Committee based on originality, quality, and relevance to theoretical computer science. The quality of the manuscripts was very high indeed, and several deserving papers had to be rejected.

ICALP 2006 consisted of four invited lectures and the contributed papers. This volume of the proceedings contains all contributed papers presented at the conference in Track A, together with the paper by the invited speaker Noga Alon (Tel Aviv University, Israel). A companion volume contains all contributed papers presented in Track B and Track C together with the papers by the invited speakers Cynthia Dwork (Microsoft Research, USA) and Prakash Panangaden (Mc Gill University, Canada). The program had an additional invited lecture by Simon Peyton Jones (Microsoft Research, UK), which does not appear in the proceedings.

ICALP 2006 was held in conjunction with the Annual ACM International Symposium on Principles and Practice of Declarative Programming (PPDP 2006) and with the Annual Symposium on Logic-Based Program Synthesis and Transformation (LOPSTR 2006). Additionally, the following workshops were held as satellite events of ICALP 2006: ALGOSENSORS 2006 - International Workshop on Algorithmic Aspects of Wireless Sensor Networks; CHR 2006 - Third Workshop on Constraint Handling Rules; CL&C 2006 - Classical Logic and Computation; DCM 2006 - 2nd International Workshop on Developments in Computational Models; FCC 2006 - Formal and Computational Cryptography; iETA 2006 - Improving Exponential-Time Algorithms: Strategies and Limitations; MeCBIC 2006 - Membrane Computing and Biologically Inspired Process Calculi; SecReT 2006 - 1st Int. Workshop on Security and Rewriting Techniques; WCAN 2006 - 2nd Workshop on Cryptography for Ad Hoc Networks.

We wish to thank all authors who submitted extended abstracts for consideration, the Program Committee for their scholarly effort, and all referees who assisted the Program Committees in the evaluation process.

Thanks to the sponsors for their support, to the Venice International University and to the Province of Venice for hosting ICALP 2006 in beautiful S. Servolo. We are also grateful to all members of the Organizing Committee in the Department of Computer Science and to the Center for Technical Support Services and Telecommunications (CSITA) of the University of Venice. Thanks to Andrei Voronkov for his support with the conference management software EasyChair. It was great in handling the submissions and the electronic PC meeting, as well as in assisting in the assembly of the proceedings.

April 2006

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fashion. Our first finding is an equivalence relation between two security notions for these protocols—we show that for a large class of such protocols, in which encryption is not nested (that is, each ciphertext is of the form $E_{K_1^*}(K_2)$) security against multiple corrupt receivers is equivalent to security against a single corrupt receiver. This equivalence holds both in the symbolic (Dolev-Yao) model (that is, symbolic security against single corruptions implies symbolic security against multiple corruptions), and, subject to some mild syntactic conditions (e.g., absence of encryption cycles), also in the computational model. The equivalence in the computational setting is, in fact, of a very strong flavor: if one can prove a protocol (within the said class) computationally secure against single corruptions for *some* implementation of the cryptographic primitives, then it is collusion-resistant for *every* implementation of the primitives satisfying standard security properties (semantic security against chosen plaintext attacks for the former and computational indistinguishability for the latter).

We exemplify the significance of this equivalence result by applying it to the security analysis of various existing protocols. (See Table 1 in Sect. 4.) Most protocols (11 out of 13) surveyed by us don't make use of nested encryption and, as such, a proof of security against single corruptions for such protocols automatically implies collusion-resistance. As a part of our analysis, we uncover security weaknesses in 7 of the surveyed protocols, and provide simple fixes that result in protocols that are provably secure against arbitrary (polynomial-time) computational attacks.

Our techniques to prove this equivalence result don't generalize to capture protocols that use nested encryption (that is, transmit ciphertexts created by iterative encryption of a key using *multiple* other keys), and, in fact, they cannot do so. We demonstrate this by constructing a protocol that uses nesting (in fact, at most two iterations of E per ciphertext suffice), is secure against single corruptions but is totally broken by malicious coalitions (of size as small as two). As with the equivalence result, our separation holds both in the symbolic and computational models of security.

Protocols like the one used in our separation result have already been known to exist [5, 7]. (We remark that both these protocols require stateful receivers while ours does not.) Such protocols have a significant advantage over collusion-resistant protocols in terms of communication efficiency (constant versus logarithmic) and, in fact, they *beat* known lower bounds on the communication cost of GKD protocols [12]. Our results provide a precise explanation for this anomaly: although the bound of [12] applies to nested-encryption protocols, it holds only when collusion-resistance is satisfied. In fact, from our equivalence theorem (and the result of [12]), it follows that the efficiency of [5, 7] is unachievable using single encryption alone; it is precisely the use of nesting (and relaxation of the security requirements) that provide the efficiency gain.

Our Approach. Our equivalence and separation results for GKD protocols are obtained using a modular two-stage approach. We first prove the results in the Dolev-Yao model (Sect. 2), treating encryption and PRGs as abstract

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