

# Lecture Notes in Computer Science

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# Computer Science Logic

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## Preface

The workshop CSL '91 (Computer Science Logic) was held at the University of Berne, Switzerland, October 7-11, 1991. It was the fifth in a series of workshops, following CSL '90 at the Max-Planck-Haus in Heidelberg, CSL '89 at the University of Kaiserslautern, CSL '88 at the University of Duisburg, and CSL '87 at the University of Karlsruhe. Forty-three talks were presented at the workshop, consisting of invited presentations and those selected from a hundred and one submissions.

In addition to the usual program of CSL meetings we had a panel discussion on the topic "Theoretische Informatik: Abstrakte Konzepte und praktische Anwendungen". It was our aim to bring together distinguished specialists from academia and industry to address this interesting and relevant issue in theoretical computer science. We thank the panelists K. Drangeid (IBM), E. Engeler (ETH Zürich), H. Lienhard (Landis & Gyr), H. Mey (Universität Bern, ASCOM Tech), P. Päppinghaus (Siemens) and M.M. Richter (Universität Kaiserslautern) for sharing their interesting views about the possible connections and interaction between theory and practice in the general field of computer science logic.

As was the case for CSL '87 (see Lecture Notes in Computer Science, Vol. 329), CSL '88 (see Lecture Notes in Computer Science, Vol. 385), CSL '89 (see Lecture Notes in Computer Science, Vol. 440), and CSL '90 (see Lecture Notes in Computer Science, Vol. 533), we collected the original contributions after their presentation at the workshop and began a review procedure which resulted in the selection of the papers in this volume. They appear here in final form.

We would like to thank the referees without whose help we would not have been able to accomplish the difficult task of selecting among the many valuable contributions. Several members of the Institut für Informatik und angewandte Mathematik of the University of Berne helped to organize the meeting and to prepare this volume, in particular Ursula Hadorn, Urs-Martin Künzi, Markus Marzetta, Robert Stärk, Thomas Strahm, Tyko Strassen and Susanne Thüler. We thank all of them for their commitment and continued support.

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May 1992

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# The Expressive Power of Transitive Closure and 2-way Multihead Automata

Yaniv Bargury\* and Johann Makowsky\*

## Abstract

It is known, that over 1-dimensional strings, the expressive power of 2-way multihead (non) deterministic automata and (non) deterministic Transitive Closure formulas is (non) deterministic log space [Ib73, Im88]. However, the subset of formulas needed to simulate exactly  $k$  heads is unknown. It is also unknown if the automata and formulas have the same expressive power over more general structures such as multidimensional grids. We define a reduction from  $k$ -head automata to formulas of arity  $k$ , which works also for grids. The method used is a generalization of [Kl56], and the formulas obtained are a generalization of regular expressions to multihead automata and to grid languages. As simple applications, we use the reduction to show that the power of formulas of arity 1 over strings define (classical) regular languages, to give a simpler equivalent of the  $L=NL$  open problem, and to establish the equivalence of the automata and formulas over grids.

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