LOGIC FOR CONCURRENCY AND SYNCHRONISATION

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Volume Editor

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LOGIC
FOR CONCURRENCY
AND SYNCHRONISATION

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Foreword

The study of information-based actions and processes has been a vibrant interface between logic and computer science for several decades now. Indeed, several natural perspectives come together here. On the one hand, logical systems may be used to describe the dynamics of arbitrary computational processes – as in the many sophisticated process logics available today. But also, key logical notions such as model checking or proof search are themselves informational processes involving agents with goals. The interplay between these descriptive and dynamic aspects shows even in our ordinary language. A word like "proof" hdenotes both a static 'certificate' of truth, and an activity which humans or machines engage in. Increasing our understanding of logics of this sort tells us something about computer science, and about cognitive actions in general.

The individual chapters of this book show the state of the art in current investigations of process calculi such as linear logic, **π-calculus,** and **μ-calculus** – with mainly two major paradigms at work, namely, linear logic and modal logic. These techniques are applied to the title themes of concurrency and synchronisation, but there are also many repercussions for topics such as the geometry of proofs, categorial semantics, and logics of graphs. Viewed together, the chapters also offer exciting glimpses of future integration, as the reader moves back and forth through the book. Obvious links include modal logics for proof graphs, labeled deduction merging modal and linear logic, Chu spaces linking proof theory and model theory, and bisimulation-style equivalences as a tool for analyzing proof processes.

The combination of approaches and the pointers for further integration in this book also suggests a grander vision for the field. In classical computation theory, Church's Thesis provided a unification and driving force. Likewise, modern process theory would benefit immensely from a synthesis bringing together paradigms like modal logic, process algebra, and linear logic – with their currently still separate worlds of bisimulations, proofs, and normalisation. If this Grand Synthesis is ever going to happen, books like this are needed!

JOHAN VAN BENTHEM, ILLC Amsterdam & CSLI Stanford

Preface

The contributions published in this volume arose in the context of the project *Logic for Concurrency and Synchonisation* (*LOCUS*) which was concerned with the relationship between proof theory (à *la* Curry–Howard-like calculi) and concurrency theory (*à la* π-calculus, μ-calculus), as well as the application of those formalisms to the verification of group-based protocols.

The project also sought to investigate the possibility of defining a unifying methodology (algebraic methods vs. logical methods) for the formalisation of distributed systems, concurrency and synchronisation, using the most recent techniques coming from mathematical logic (in particular, labelled deduction, type theory, and modal logic), proof theory and semantics of concurrent processes.

Four institutions participated in the project: Universidade Federal de Pernambuco (UFPE), Universidade Federal de Alagoas (UFAL), Universidade Federal da Bahia (UFBA), and Universidade Federal do Rio de Janeiro (UFRJ).

Outline

Chapter 1 reviews a collection of recent and less recent work around graph-theoretical tools used in proof theory, leading to some ideas for bringing together the old (e.g., Kneale's symmetric proof system) and the new (Girard's graph-theoretic criterion to check soundness of graphs of proof) in order to further enhance the tools for the understanding of natural deduction (ND): the geometry of interaction of ND-proofs, their lack of symmetry and their proof complexity.

In Chapter 2, Bellin argues that the essential interaction between classical and intuitionistic features in the system of linear logic is best described in the language of category theory. The main result is to show that the intuitionistic translations induced by Girard's trips determine the functor from the free $*$-autonomous category $\mathcal{A}$ on a set of atoms $\{P, P', \ldots\}$ to $\mathcal{C} \times \mathcal{C}^{op}$, where $\mathcal{C}$ is the free monoidal closed category with products and coproducts on the set of atoms $\{P_O, P_I, P'_O, P'_I, \ldots\}$ (a pair P_O, P_I in $\mathcal{C}$ for each atom P of $\mathcal{A}$).

In Chapter 3, Bellin proposes a notion of *symmetric reduction* for a system of proof-nets for *Multiplicative Affine Logic with Mix* (**MAL** + Mix) (namely, multiplicative linear logic with the mix-rule the unrestricted weakening-rule), and proves that such a reduction has the strong normalisation and Church–Rosser properties.

In Chapter 4, Dam studies the problem of verifying general temporal and functional properties of mobile and dynamic process networks, cast in terms of the π-calculus.

In Chapter 5, Déharbe gives a tutorial introduction to CTL model checking and its symbolic BDD-based version implementation.

In Chapter 6, Benevides presents modal logics for four classes of finite graphs: finite directed graphs, finite acyclic directed graphs, finite undirected graphs and finite loopless und irected graphs.

In Chapter 7, Stirling looks at the relationships between bisimulation equivalence and language equivalence.

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Recife, February 2003

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