# DIRECTED UNFOLDING

*Reachability Analysis of Concurrent Systems*
*& Applications to Automated Planning*

by

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# Abstract

The factored state representation and concurrency semantics of Petri nets are closely related to those of classical planning models, yet automated planning and Petri net analysis have developed independently, with minimal and mainly unconvincing attempts at cross-fertilisation. This thesis exploits the relationship between the formal reachability problem, and the automated planning problem, via Petri net unfolding, which is an attractive reachability analysis method for highly concurrent systems as it facilitates reasoning about independent sub-problems. The first contribution of this thesis is the theory of *directed unfolding*: controlling the unfolding process with informative strategies, for the purpose of optimality and increased efficiency. The second contribution is the application of directed unfolding to automated planning.

Inspired by well-known planning heuristics, this thesis shows how problem specific information can be employed to guide unfolding, in response to the formal problem of developing efficient, directed reachability analysis methods for concurrent systems. Complimenting this theoretical work, this thesis presents a new forward search method for partial order planning which can be exponentially more efficient than state space search.

Our suite of planners based on directed unfolding can perform optimal and suboptimal classical planning subject to arbitrary action costs, optimal temporal planning with respect to arbitrary action durations, and address probabilistic planning via replanning for the most likely path. Empirical results reveal directed unfolding is competitive with current state of the art automated planning systems, and can solve Petri net reachability problems beyond the reach of the original "blind" unfolding technique.

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For my parents.

# Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

Sarah Hickmott

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