



Contents

Acknowledgments	i
Abstract	iii
Zusammenfassung	v
Preface	vii
I Approximation Algorithms for Conflict-free Vehicle Routing on Bidirectional Networks	1
1 Introduction	3
1.1 Problem Formulation	4
1.2 Related Work	5
1.3 Outline	7
2 Hardness Results	9
2.1 On Paths	9
2.2 On Directed Trees	14
3 Approximation Algorithms	19
3.1 Tree Approximation	19
3.2 Hot Spot Routing	23
3.3 Low-Stretch Routing	25
4 Conclusion	31



II	Conflict-free Vehicle Routing in Personal Rapid Transit	33
5	Introduction	35
5.1	Personal Rapid Transit	35
5.2	Control Challenges in PRT	39
5.3	Routing Literature	41
5.4	Outline	42
6	Routing Model	45
6.1	Network	45
6.2	Requests and Pods	46
6.3	Discrete Dynamics and Conflict Notion	47
6.4	Online Routing	49
6.5	Objective Function	50
6.6	Online Optimization	52
6.7	Model Statement	53
7	Network Capacity	55
7.1	Definition	55
7.2	Relaxed Network Capacity	57
8	Routing Preliminaries	59
8.1	Feasibility	59
8.2	Time Expansion	60
8.3	Flow Formulation	62
8.3.1	Offline Formulation	62
8.3.2	Online Formulation	64
9	Computational Complexity	67



<i>CONTENTS</i>	xi
10 Routing Algorithms	73
10.1 Sequential Routing	74
10.2 Push Routing	76
10.3 Flow Routing	78
10.3.1 Solving the Flow Relaxation	79
10.3.2 Rounding	84
10.3.3 Extensions	87
11 Computational Analysis	89
11.1 Grid Scenario	89
11.1.1 Comparison of Algorithms	90
11.1.2 Delay Types	94
11.1.3 Computation Times	96
11.1.4 Delay Horizon Trade-off in Flow Routing	97
11.1.5 Variants of Sequential Routing	98
11.1.6 Optimality Gap in the Offline Case	98
11.1.7 Variable Demand	100
11.2 Case Study	101
12 Conclusion	107