

CONTENTS

Introduction	1
1 The Network Signal Coordination Problem	7
1.1 Introduction to Coordination of Signals in Networks	7
1.1.1 The Language of Traffic Signals	7
1.1.2 Optimizing Traffic Lights	9
1.1.3 Software to Optimize Coordination	11
1.2 The Network Signal Coordination (NSC) Problem	13
1.2.1 Definition of the NSC	13
1.2.2 The Relation Between the NSC and the PESP	15
1.2.3 NP-completeness of the c-NSC problem	17
1.3 A Revised MIP Formulation for the NSC problem	18
1.3.1 Introduction	19
1.3.2 The Offsets	20
1.3.3 The Cycle Equations	23
1.3.4 A Variable Phase Sequencing	26
1.3.5 The Objective Function	27
1.3.6 Non-uniform Cycle-lengths	30
1.3.7 The Mixed-Integer Linear Program	34
1.4 Application of the NSC Model in Practice	36
1.5 Conclusion and Open Questions	37
2 Strictly Fundamental Cycle Bases on Grids	39
2.1 Introduction	39
2.2 Preliminaries	42
2.3 Lower Bounds	43
2.3.1 A New Asymptotical Lower Bound	43
2.3.2 The Challenge of Small Grids	54
2.3.3 The Amaldi MIP for the General MSFCB Problem	58
2.3.4 A new MIP formulation	63
2.3.5 A Tight Bound for $G_{8,8}$	67
2.4 Upper Bounds	73
2.4.1 A New Asymptotical Upper Bound	75

2.5	Experiments	81
2.6	Conclusions and Open Questions	82
3	Classification of Tree Spanner Problems	87
3.1	Introduction	87
3.2	A Unified Notation for Tree Spanners (UNTS)	89
3.3	MAXIMUM STRETCH Problems	91
3.3.1	Coincidences	92
3.3.2	Anticoincidences	95
3.4	AVERAGE STRETCH Problems	96
3.4.1	Coincidences	97
3.4.2	Anticoincidences	98
3.5	MAX-STRETCH And AVERAGE-STRETCH Problems Never Coincide . .	103
3.6	First Benefit of the UNTS	105
3.6.1	An Open Complexity Status	106
3.6.2	Inapproximability of the MMST Problem	109
3.7	Conclusions and Open Questions	110
4	Experiments	111
4.1	A MIP Solver Comparison on Selected NSC Instances	111
4.2	The Influence of Cycle Bases on the MIP Performance	117
4.3	Case Studies	122
4.3.1	Evaluating an NSC model	122
4.3.2	Data Acquisition	124
4.3.3	Portland	125
4.3.4	Denver	129
4.4	Conclusion and Open Questions	132
	Bibliography	135
	Index	143