

Table of Contents

1. Introduction	1
2. A Hierarchy of Constants	13
2.1 A Taxonomy of Constants	16
2.1.1 Flow Graphs	16
2.1.2 May- and Must-Constants	17
2.1.3 Weakened Constant Detection Problems	19
2.1.4 Classes of Integer Constants	21
2.2 Known Results	22
2.3 New Undecidability Results	24
2.4 New Intractability Results	25
2.5 Summary	29
3. Deciding Constants by Effective Weakest Preconditions	31
3.1 Presburger and Polynomial Constants	32
3.2 Presburger-Constant Detection at a Glance	33
3.3 A Generic Algorithm	37
3.4 Detection of Presburger Constants	40
3.5 A Primer on Computable Ideal Theory	43
3.6 More About $\mathbb{Z}[x_1, \dots, x_n]$	45
3.6.1 $\mathbb{Z}[x_1, \dots, x_n]$ as a Complete Lattice	45
3.6.2 Zeros	45
3.6.3 Substitution	46
3.6.4 Projection	46
3.7 Detection of Polynomial Constants	47
3.8 Conclusion	49
4. Limits of Parallel Flow Analysis	53
4.1 A Motivating Example	55
4.2 Parallel Programs	56
4.3 Interprocedural Copy-Constant Detection	57
4.3.1 Two-Counter Machines	58
4.3.2 Constructing a Program	59
4.3.3 Correctness of the Reduction	62

4.4	Intraprocedural Copy-Constant Detection	62
4.5	Copy-Constant Detection in Loop-Free Programs	66
4.6	Beyond Fork/Join Parallelism	67
4.7	Owicki/Gries-Style Program Proofs	67
4.8	Correctness of the Reduction in Section 4.3	68
4.8.1	Enriching the Program	68
4.8.2	The Proof Outlines	69
4.8.3	Interference Freedom	72
4.9	Correctness of the Reduction in Section 4.4	73
4.9.1	Enriching the Program	73
4.9.2	An Auxiliary Predicate	73
4.9.3	Proof Outline for π_0	74
4.9.4	Proof Outline for $\pi_i(r)$	75
4.9.5	Proof Outline for <i>Main</i>	76
4.9.6	Interference Freedom	77
4.10	Conclusion	78
5.	Parallel Flow Graphs	81
5.1	Parallel Flow Graphs	82
5.2	Operational Semantics	84
5.3	Atomic Runs	86
5.4	The Run Sets of Ultimate Interest	87
5.5	The Constraint Systems	88
5.5.1	Same-Level Runs	88
5.5.2	Inverse Same-Level Runs	90
5.5.3	Two Assumptions and a Simple Analysis	91
5.5.4	Reaching Runs	92
5.5.5	Terminating Runs	94
5.5.6	Bridging Runs	94
5.5.7	The General Case	96
5.6	Discussion	98
6.	Non-atomic Execution	101
6.1	Modeling Non-atomic Execution by Virtual Variables	103
6.2	A Motivating Example	105
6.3	The Domain of Non-atomic Run Sets	106
6.3.1	Base Statements	107
6.3.2	Sequential Composition	108
6.3.3	Interleaving Operator	108
6.3.4	Pre-operator	109
6.3.5	Post-operator	109
6.4	Conclusion	109

7. Dependence Traces	111
7.1 Transparency and Dependences	113
7.2 Dependence Traces	114
7.3 Implication Order	116
7.4 Subsumption Order	117
7.5 A Lattice of Antichains	118
7.6 Short Dependence Traces	121
7.7 The Abstract Domain	124
7.8 Pre-operator	126
7.9 Post-operator	128
7.10 Sequential Composition	128
7.11 Interleaving	130
7.11.1 Complementary Dependence Traces	131
7.11.2 Interleaving Operator	132
7.11.3 Soundness Lemmas	132
7.11.4 Completeness Lemmas	136
7.11.5 Proof of Theorem 7.11.1	139
7.12 Base Edges	140
7.13 Running Time	141
7.14 Discussion	142
8. Detecting Copy Constants and Eliminating Faint Code	145
8.1 Copy-Constant Detection	146
8.2 Faint-Code Elimination	148
8.3 Running Time	150
8.4 Conclusion	152
9. Complexity in the Non-atomic Scenario	153
9.1 The SAT-reduction	154
9.2 Towards Stronger Lower Bounds	156
9.2.1 Assignment Statements That Propagate Twice	157
9.2.2 Propagating Runs of Exponential Length	159
9.3 Summary	160
10. Conclusion	161
10.1 Future Research	163
A. A Primer on Constraint-Based Program Analysis	165
References	173

Variations on Constants

Flow Analysis of Sequential and Parallel Programs

Müller-Olm, M.

2006, XIII, 177 p., Softcover

ISBN: 978-3-540-45385-7