

Contents

1	Introduction	1
2	Types Made Explicit	7
2.1	The Typed λ -Calculus	8
2.2	Type Analysis	12
2.2.1	Polytypes	13
2.2.2	The algorithm	16
2.2.3	Syntactic soundness and completeness	22
3	Binding Time Made Explicit	33
3.1	The 2-Level λ -Calculus	33
3.2	Binding Time Analysis	46
3.2.1	Binding time analysis of types	48
3.2.2	Binding time analysis of expressions	55
3.2.3	Binding time analysis of programs	68
3.3	Improving the Binding Time Analysis	72
4	Combinators Made Explicit	79
4.1	Mixed λ -Calculus and Combinatory Logic	80
4.1.1	Well-formedness	83
4.1.2	Combinator expansion	86
4.2	Combinator Introduction	88
4.3	Improving the Combinator Introduction	102
5	Parameterized Semantics	107
5.1	Types	107
5.1.1	Domain theory	108
5.1.2	Interpretation of types	116
5.2	Expressions	122
5.3	Programs	133

vi	Contents
6	Code Generation 139
6.1	The Coding Interpretation 139
6.1.1	First order aspects of the abstract machine 143
6.1.2	First order aspects of the coding interpretation 144
6.1.3	Recursion 148
6.1.4	Higher-order aspects 152
6.2	The Substitution Property 154
6.3	Well-behavedness of the Code 163
6.3.1	Definition of the well-behavedness predicates 165
6.3.2	Operations on execution sequences 168
6.3.3	Well-behavedness of operators 170
6.4	Correctness of the Code 185
6.4.1	Definition of the correctness predicates 185
6.4.2	Correctness of operators 188
7	Abstract Interpretation 207
7.1	Strictness Analysis 207
7.1.1	Types 208
7.1.2	The safety property 214
7.1.3	Expressions 219
7.1.4	Proof of safety 222
7.2	Improved Strictness Analysis 232
7.2.1	The Case construct 232
7.2.2	Tensor products 237
8	Conclusion 253
8.1	Optimized Code Generation 253
8.1.1	Using local strictness information 254
8.1.2	Using right context information 257
8.1.3	Using left context information 261
8.1.4	Pre-evaluation of arguments 266
8.2	Denotational Semantics 268
8.2.1	The language Imp 269
8.2.2	Transformations on the semantic specification 272
8.2.3	Towards a compiler 278
8.3	Research Directions 280
	Bibliography 285
	Summary of Transformation Functions 293
	Index 295