

Contents

1	Preface	1
2	The Weight Finder - An Advanced Profiler for Fortran Programs	7
	<i>by Thomas Fahringer</i>	
2.1	Introduction	7
2.2	Prerequisite	10
2.3	The Weight Finder	10
2.3.1	Choosing sequential program parameters	11
2.3.2	Instrumentation	13
2.3.3	Optimization	16
2.3.4	Compile and Execute	19
2.3.5	Attribute and Visualize	19
2.4	Adaptation of Profile Data	19
2.4.1	Program transformations	20
2.4.2	Problem Size	24
2.5	Conclusion and Future Work	25
3	Predicting Execution Times of Sequential Scientific Kernels	32
	<i>by Neil B. MacDonald</i>	
3.1	Motivation	32
3.2	Deriving time formulae for code fragments	33
3.3	Obtaining a platform model	34
3.4	Examples	37
3.4.1	Fragment A	37
3.4.2	Fragment B	38
3.4.3	Fragment C	39
3.4.4	Fragment D	40
3.4.5	Fragment E	41
3.4.6	Fragment F	42
3.4.7	Summary of results	43
3.5	Discussion and Further Work	43
4	Isolating the Reasons for the Performance of Parallel Machines on Numerical Programs	45
	<i>by Arno Formella, Silvia M. Müller, Wolfgang J. Paul, and Anke Bingert</i>	
4.1	Introduction	45
4.2	Micro Measurements	46
4.2.1	Micro Measurements for a Node Processor	47
4.2.2	Micro Measurements for Communication Networks	52
4.3	Measurements	56
4.3.1	Measurements of the Serial Kernels	56

4.3.2	Measurements of the Parallel Kernels	62
4.4	Algorithms	67
4.4.1	CG-method	67
4.4.2	PDE1-method	69
4.4.3	PDE2-method	70
4.5	Analysis of the Programs	71
4.5.1	Serial Versions	71
4.5.2	Parallel Versions	73
4.6	Conclusion	76
5	Targeting Transputer Systems, Past and Future	78
	<i>by Denis Nicole</i>	
5.1	Introduction	78
5.2	The T800 family	79
5.3	The T9000 family	81
5.4	The Chameleon family	82
6	Adaptor: A Compilation System for Data Parallel Fortran Programs	84
	<i>by Thomas Brandes</i>	
6.1	Introduction	84
6.2	The Adaptor Compilation System	85
6.2.1	Properties of Adaptor	85
6.2.2	Overview of Adaptor	86
6.2.3	The Input Language	87
6.2.4	Programming Models for the Generated Programs	87
6.2.5	Interactive Source-to-Source Transformation	87
6.2.6	Realization of the Translation	88
6.2.7	Distributed Array Library	89
6.2.8	Visualization of the Run Time Behavior	90
6.2.9	Availability	90
6.2.10	Related Work	90
6.3	Results of Benchmark Codes	90
6.3.1	The Purdue Set	91
6.3.2	Comparison of Sequential and Parallel Version	91
6.3.3	Efficiency and Scalability	92
6.3.4	Adaptor vs. hand-coded message passing programs	93
6.3.5	Full vs. Loosely Synchronous Execution	93
6.4	Results of Application Codes	95
6.4.1	HYDFLO: a CM Fortran Code for Fluid Dynamics	95
6.4.2	ESM: a Fortran 90 Code for Circulation	95
6.4.3	IFS: a Fortran 77 Code for Weather Prediction	95
6.5	Summary	96
7	SNAP! Prototyping a Sequential and Numerical Application Parallelizer	99
	<i>by Rolf Hähnisch</i>	
7.1	Introduction	99

7.2	Compiler	100
7.2.1	Front-End for FORTRAN	100
7.2.2	Dependence Analysis	101
7.2.3	Alignment analysis	102
7.2.4	Parallelizer	102
7.2.5	Code generation	103
7.3	Conclusions	108
8	Knowledge-Based Automatic Parallelization by Pattern Recognition	
	<i>by Christoph W. Kefler</i>	
8.1	Introduction and Overview	110
8.2	Preprocessing the Source Code	112
8.3	Which Patterns are Supported?	115
8.4	Pattern Recognition: A Detailed View	116
8.4.1	Program Representation	117
8.4.2	Pattern Hierarchy Graph	118
8.4.3	The Matching Algorithm	119
8.4.4	Standard Pattern Matching: A simple example	120
8.4.5	Removing redundant IF statements	121
8.4.6	Loop Rerolling	122
8.4.7	Difference Stars	125
8.4.8	Beyond standard matching: Identification of multigrid hierarchies	126
8.5	A Parallel Algorithm for each Pattern	127
8.6	Alignment and Partitioning	128
8.7	Determining Cost Functions: Estimating and Benchmarking	130
8.8	Implementation and Future Extensions	130
8.9	Conclusions	132
9	Automatic Data Layout for Distributed-Memory Machines in the D Programming Environment	136
	<i>by Ulrich Kremer, John Mellor-Crummey, Ken Kennedy, and Alan Carle</i>	
9.1	Introduction	136
9.2	Compilation system	137
9.3	Dynamic Data Layout: Two Examples	138
9.4	Towards Dynamic Data Layout	142
9.4.1	Alignment Analysis	142
9.4.2	Distribution Analysis	143
9.4.3	Inter-Phase Decomposition Analysis	143
9.5	Related Work	146
9.6	Summary and Future Work	147
10	Subspace Optimizations	153
	<i>by Kathleen Knobe and William J. Dally</i>	
10.1	Introduction	153
10.1.1	Data Optimization	154
10.1.2	Shapes	155

10.2	Subspaces	157
10.3	Subspace Changes	158
10.3.1	Scalars	159
10.3.2	Control Expressions	160
10.3.3	Array Sections	161
10.3.4	Explicit Dimensions	162
10.3.5	Reductions	163
10.4	Subspace Optimizations	164
10.4.1	Relative Costs	165
10.4.2	Subspace Minimization	166
10.4.3	Subspace Minimization with other Types of Expansion	169
10.4.4	Combining Multiple Expansions	170
10.4.5	Expansion Strength Reduction	171
10.4.6	Expansion Costs	172
10.4.7	Reducing the Computation within Expansions	173
10.5	Subspaces Optimization Compared to Alignment	174
10.6	Summary	175
10.7	Acknowledgments	175
11	Data and Process Alignment in Modula-2*	177
	<i>by Michael Philippsen and Markus U. Mock</i>	
11.1	Introduction	177
11.2	Modula-2*	178
11.2.1	FORALL statement	179
11.2.2	Allocation of array data	179
11.3	Alignment in Modula-2*	180
11.3.1	Data Alignment	181
11.3.2	Process Alignment	182
11.4	Arrangement Graphs and Conflicts	183
11.4.1	Type and Structure	183
11.4.2	Conflicts	184
11.5	Cost Considerations	187
11.6	Example	188
11.7	Conclusion	189
12	Automatic Parallelization for Distributed Memory Multiprocessors	192
	<i>by Anne Dierstein, Roman Hayer, and Thomas Rauber</i>	
12.1	Introduction	192
12.2	Related Work	193
12.3	Overview	194
12.4	Parallelization Strategy	195
12.5	Branch-and-Bound Algorithm	199
12.5.1	Basic Approach	199
12.5.2	Distribution Graph	201
12.5.3	Redistribution during Program Execution	204
12.6	Performance Estimator	205

12.6.1	Transfer costs	206
12.6.2	Combining the transfer costs	209
12.6.3	Data Transfer Graph	210
12.7	Prototype Implementation and Results	212
12.7.1	Implementation	212
12.7.2	Livermore Loops	212
12.7.3	Gauss–Seidel Relaxation	213
12.7.4	Jacobi Relaxation	214
12.8	Conclusions and Further Research	215
12.9	Acknowledgements	216
A	Trademarks	218