

Contents

Preface	xi
1 Introduction	1
1.1 Basic approaches	4
1.1.1 Programmed systems	4
1.1.2 Trainable systems	14
1.2 Fundamental system aspects	17
1.3 Application areas	18
1.3.1 Image processing	19
1.3.2 Mathematical modelling	21
1.3.3 Artificial intelligence	25
1.3.4 General database manipulation	27
1.4 Summary	28
2 The Paradigms of Parallel Computing	30
2.1 Flynn’s taxonomy	31
2.2 Pipelining	32
2.3 MIMD	37
2.4 Graph reduction	41
2.5 SIMD	47
2.6 Systolic	52
2.7 Association	59
2.8 Classification	64
2.9 Transformation	70
2.10 Minimisation	71
2.10.1 Local minimisation	72
2.10.2 Global minimisation	74
2.11 Confusion compounded	75
2.11.1 The vector supercomputer	77
2.12 Exercises	78
3 Programming Parallel Computers	80
3.1 Parallel programming	80
3.1.1 The embodiment of parallelism	80
3.1.2 The programming paradigm	84
3.1.3 The level of abstraction	94

viii	<i>Contents</i>	
	3.2 Parallel languages	103
	3.2.1 Fortran	104
	3.2.2 Occam	106
	3.2.3 Parlog	108
	3.2.4 Dactl	109
	3.3 Cognitive training	111
	3.3.1 Hebb's rule	113
	3.3.2 Simulated annealing	115
	3.3.3 Back propagation	118
	3.4 Conclusions	120
	3.5 Exercises	121
4	Connectivity	123
	4.1 Synchronising communications	124
	4.2 The role of memory	126
	4.3 Network designs	130
	4.3.1 The bus	134
	4.3.2 The crossbar switch	138
	4.3.3 Near neighbours	139
	4.3.4 Trees and graphs	143
	4.3.5 The pyramid	147
	4.3.6 The hypercube	150
	4.3.7 Multistage networks	153
	4.3.8 Neural networks	155
	4.4 Reconfigurable networks	159
	4.5 System interconnections	161
	4.6 Conclusions	162
	4.7 Exercises	164
5	Processor Design	166
	5.1 Analogue or digital?	166
	5.2 Precision	168
	5.3 Autonomy	170
	5.3.1 Variously-autonomous processors	171
	5.4 Instruction set complexity	174
	5.5 Technology	174
	5.5.1 Basic materials	175
	5.5.2 Device types	176
	5.5.3 Scale of fabrication	176
	5.6 Three design studies	177
	5.6.1 An MIMD computer for general scientific computing	178
	5.6.2 An SIMD array for image processing	182
	5.6.3 A cognitive network for parts sorting	188

	<i>Contents</i>	<i>ix</i>
5.7	Conclusions	190
5.8	Exercises	191
6	System Performance	193
6.1	Basic performance measures	194
6.1.1	Clock rate	194
6.1.2	Instruction rate	195
6.1.3	Computation rate	195
6.1.4	Data precision	195
6.1.5	Memory size	195
6.1.6	Addressing capability	196
6.2	Measures of data communication	196
6.2.1	Transfer rate	197
6.2.2	Transfer distance	199
6.2.3	Bottlenecks	202
6.3	Multiplication factors	203
6.4	The effects of software	205
6.5	Cognitive systems	206
6.6	Benchmarking	207
6.6.1	A brief survey of benchmarks	208
6.6.2	Case studies	210
6.7	Defining and measuring costs	220
6.7.1	Hardware	220
6.7.2	Software	220
6.7.3	Prototyping and development	221
6.8	Summary and conclusions	221
6.9	Exercises	222
7	Some Case Studies	224
7A	Datacube contributed by D. Simmons	226
7B	Cray contributed by J. G. Fleming	236
7C	nCUBE contributed by R. S. Wilson	246
7D	Parsys contributed by D. M. Watson	256
7E	GRIP contributed by C. Clack	266
7F	AMT DAP contributed by D. J. Hunt	276
7G	MasPar MP-1 contributed by J. R. Nickolls	287
7H	WASP contributed by I. Jaloweicki	296
7I	WISARD contributed by C. Myers	309
8	Conclusions	320
8.1	A taxonomy of systems	320
8.2	An analysis of alternatives	326

x	<i>Contents</i>	
	8.2.1 The user interface	326
	8.2.2 Generality of application	328
	8.2.3 Technical issues	330
	8.2.4 Efficiency	331
	8.2.5 Summary	332
8.3	The future	332
	8.3.1 Commercial	333
	8.3.2 Architectures	334
	8.3.3 Technology	334
	8.3.4 User interfaces	336
8.4	Concluding remarks	336
	Bibliography	337
	References	338
	Index	343