Contents

1	Introduction 1							
	1.1	Contributions						
	1.2	Organisation						
2	Arc	Architecture						
	2.1	Architectural Models						
	2.2	Architectural Flexibility 11						
		2.2.1 Classifying Customisations						
		2.2.2 Cost of Flexibility						
	2.3	Architectural Design Space Exploration						
		2.3.1 Classifying Architectural Explorations						
		2.3.2 Ranking Architectural Merits						
	2.4	Multi-core Architectures						
		2.4.1 Commercial Multi-core Processors						
		2.4.2 Limitations of Existing Multi-core architectures						
	2.5	Initiatives for Customisable Multi-core Processors						
	2.6	The Concept: Run-time Reconfigurable Multiprocessors						
		2.6.1 Reconfiguration Mechanism						
		2.6.2 Advantages of the New Reconfiguration Mechanism 29						
	2.7	7 Summary						
3	Application 33							
	3.1	Programmability						
	3.2	Methods of Application Description						
		3.2.1 Application Description for Parallel Processors						
		3.2.2 Managing Communication and Synchronisation						
		3.2.3 Drawbacks of Existing Methods						
	3.3	Architecture-Independent Application Characteristics						
		3.3.1 Model for Computation						
		3.3.2 Model for Synchronisation						
		3.3.3 Model for Communication						
	3.4	Comparing Application-specific Attributes						
		3.4.1 DSP Applications						

		3.4.2	Multiplier used in Elliptic Curve Cryptography	48						
		3.4.3	Self-organising Maps	50						
		3.4.4	Priorities: Computation, Communication, or Synchronisation	51						
	3.5	Restat	ting Amdahl's Law	54						
		3.5.1	Speedup: Comparison to Amdahl's Law	55						
		3.5.2	Power: Comparison to Amdahl's Law	58						
		3.5.3	Impact on Energy	59						
	3.6	Summ	ary	61						
4	App	plication to Architectural Mapping 63								
	4.1	Applie	cations and Architectures: Fixed vs. Alterable	64						
		4.1.1	Fixed Applications, Fixed Architecture	65						
		4.1.2	Alterable Applications, Fixed Architecture	66						
		4.1.3	Fixed Application, Alterable Architectures	67						
		4.1.4	Alterable Applications, Alterable Architecture	68						
	4.2	Applie	cation Mapping: Objectives and Methods	69						
		4.2.1	Compilation Flow	69						
		4.2.2	FPGA Flow	72						
		4.2.3	Comparing the two Design Flows	74						
		4.2.4	Merging Compilation and Synthesis Design Flows	76						
		4.2.5	Considerations for Merging Spatial and Temporal Design Flows	76						
		4.2.6	Optimisation Objectives	78						
		4.2.7	Cost Function	79						
	4.3	Adapt	ive Mapping in Reconfigurable Multiprocessors	79						
		4.3.1	Reconfiguration for Application Mapping	80						
		4.3.2	Advantages of the Multi-dimensional Mapping Approach	85						
	4.4	Summ	ary	85						
5	Qua	droCo	re: Architecture	87						
	5.1	Beconfiguration Design Space								
		5.1.1	Instruction to Control Reconfiguration	89						
		5.1.2	Synchronisation	91						
		5.1.3	Communication	93						
		5.1.4	MIMD and SIMD operation	96						
		5.1.5	Word-length Configurability	97						
		5.1.6	Additional Instructions for Co-operative Multiprocessing	99						
		5.1.7	Compilation Flow	99						
	5.2	2 Time and Power Characteristics								
		5.2.1	Timing Characteristics	101						
		5.2.2	QuadroCore Power Distribution	101						

		5.2.3	Time and Power variations in the Reconfiguration Design Space	103						
	5.3	Instru	ction-level Power Model	104						
		5.3.1	Instruction Life Cycle	106						
		5.3.2	Memory Accesses	107						
		5.3.3	Register Accesses	108						
		5.3.4	ALU Accesses	108						
		5.3.5	Multiprocessor Synchronisation	108						
		5.3.6	Instruction Set Characterisation	109						
	5.4	Impact of Compilation Techniques								
	5.5	Impler	Implementation and Performance Measurements							
		5.5.1	Standard Cell Implementation	116						
		5.5.2	Post-layout Implementation Reports	120						
		5.5.3	FPGA Reports	. 121						
	5.6	Summ	ary	. 122						
6	QuadroCore: Applications 12									
	6.1	Design	Flow for Resource Efficiency	126						
	6.2	Applic	ations Mapped to QuadroCore	127						
		6.2.1	Timing Advantage of Reconfiguration	128						
		6.2.2	DSP Algorithms	. 129						
		6.2.3	Multiplier used in Elliptic Curve Cryptography	132						
		6.2.4	Self-organising Maps	136						
		6.2.5	Comparison: Parallelism, Speedup, Energy	140						
		6.2.6	Comparable Architectures	. 141						
	6.3	Extend	ling the QuadroCore Multiprocessor	143						
		6.3.1	Platform for Validating Parallel Programs	143						
		6.3.2	Environment for Run-time Processor Customisation	144						
	6.4	Summ	ary	. 145						
7	Con	clusion	s and Future Work	147						
	7.1	Summ	ary	. 148						
	7.2	Future	Work	. 150						
Glossary 1 List of Figures 1										
										List of Tables
References										
Author's Publications										