

Contents

1	Models of Parallel Computers	5
1.1	Single Instruction Stream Single Data Stream (SISD)	5
1.2	Multiple Instruction Stream Single Data Stream (MISD)	6
1.3	Single Instruction Stream Multiple Data Stream (SIMD)	6
1.4	Shared vs. Distributed Memory	7
1.5	PRAM model	9
1.5.1	Simulating multiple accesses on EREW PRAM	11
1.6	Multiple Instruction Stream Multiple Data Stream (MIMD)	11
1.7	SIMD vs. MIMD	12
2	Complexity Analysis of Parallel Algorithm	14
2.1	Analyzing sequential algorithms	14
2.2	Analyzing parallel algorithms	15
3	Interconnections Topologies for Multiprocessor Systems	17
3.1	Notation and terminology	17
3.2	Characteristics of the interconnection topologies	18
3.3	Binary hypercube of dimension n , Q_n	19
3.4	Meshes	21
3.4.1	n -dimensional mesh of dimensions $z_1, z_2, \dots, z_n$, $M(z_1, z_2, \dots, z_n)$	21
3.4.2	n -dimensional torus of dimensions $z_1, z_2, \dots, z_n$, $T(z_1, z_2, \dots, z_n)$	21
3.4.3	Multigrids	22
3.5	Hypercubic networks	23
3.5.1	Cube-connected cycles of dimension n , CCC_n	23
3.5.2	Butterfly of dimension n	24
3.6	Trees	25
3.6.1	Complete d -ary tree of height n , $CT_{d,n}$	25
3.6.2	Pyramid of height n , P_n	26
3.6.3	Fat trees	26
3.6.4	2D-mesh of trees of height n , MT_n	27
3.7	De Bruin and Kautz networks	27
3.8	Cayley graphs	29
4	Embeddings and Simulations	30
4.1	Notation and definitions	30
4.2	Embedding into hypercubes	32
4.2.1	Embeddings of trees	32
4.2.2	Embeddings of meshes-of-trees	34
4.2.3	Embeddings of meshes	34
4.2.4	Embeddings of X-trees and pyramids	35
4.2.5	Embeddings of hypercubic networks	35
4.2.6	Embeddings of other graphs	36
4.3	Embeddings into meshes	36

4.4	Pyramids and meshes-of-trees	36
4.5	Embeddings into hypercubic networks	37
4.6	Embeddings into de Bruin and Kautz digraphs	37
5	Communication Issues	38
5.1	Introduction	38
5.2	Routing algorithms	38
5.2.1	Routing technology	39
5.2.2	Single one-to-one routing	40
5.2.3	Permutation routing	41
5.3	Broadcasting algorithms	43
5.4	Broadcasting in the hypercube	44
5.4.1	One-to-all broadcast	45
5.4.2	All-to-all broadcast	46
5.4.3	One-to-all scatter	48
5.4.4	All-to-all scatter	50
5.5	Broadcasting in other graphs	52
6	Parallel Algorithms	52
6.1	Parallel prefix computation	52
6.2	Parallel sorting algorithms	54
6.2.1	Mesh-based oblivious sorting	54
6.2.2	Sorting on hypercubic networks	55
6.3	Parallel algorithms for linear algebra	56
6.3.1	Parallel vector and matrix computations	57
6.3.2	Parallel algorithms for solving linear equations	59
6.3.3	Parallel direct algorithms for solving SLE	61
6.3.4	Parallel iterative algorithms for solving SLEs	62
6.4	Discretization of PDE and multigrid methods	64
6.5	Convex-hull algorithms on hypercube	65
7	Parallel Virtual Machine	67
7.0.1	Architecture of PVM	68
7.0.2	C routines in PVM library	70
7.0.3	Programming in PVM	73
7.0.4	Perspectives of PVM	73