Contents

Part I Exascale Computing: New Challenges in Software and Hardware

ре	yona	Example Computing: Reacting the Frontiers of ringh	
Pe	rform	nance Computing	3
Mi	chael	M. Resch	
1	Intro	duction	3
2	History		4
	2.1	Architecture in Review	4
3	Situation		5
	3.1	Processors	6
	3.2	Networks	7
	3.3	Architectures	7
4	Pote	ntial Paths Forward	8
	4.1	Exaflops	9
5	Disc	ussion	9
	5.1	Hardware Issues	10
	5.2	Software Issues	10
	5.3	Modeling Issues	11
6	Sum	mary	11
Re	feren	ces	11
Ar	chite	ctural Considerations for Exascale Supercomputing	13
Ya	suo Is	shii	
1	Intro	oduction	13
2	Dens	se Matrix–Matrix Multiplication	14
	2.1	DGEMM Algorithm	14
3	Arch	nitecture Design Pattern	15
	3.1	Subword-SIMD	16
	3.2	SIMT	16
	3 3	Vector-SIMD	17

viii Contents

4		gorithm for Each Architecture	17
5	Architecture	Consideration for Exascale Supercomputing	19
	5.1 Compa	arison with Existing Architectures	21
	5.2 Discuss	sion	23
6	Summary		23
Re	ferences		24
Pa	rt II Techni Systen	iques and Tools for New-Generation Computing	
н	•	ng with Hierarchical Abstractions to Help	
		ition	27
Hi: Su	-	wa, Ryusuke Egawa, Daisuke Takahashi, and Reiji	
1			28
2		ig Models and HPC Refactoring Tools	30
3		Libraries for Heterogeneous Computing Systems	30
4		ain-Specific Knowledge	31
5		PC Refactoring	31
6	Conclusions	· · · · · · · · · · · · · · · · · · ·	32
Re	ferences		32
Ex	oloring a De	esign Space of 3-D Stacked Vector Processors	35
		, Jubee Tada, and Hiroaki Kobayashi	
1	_	· L	35
2	3-D Die Stad	cking Technologies	37
	2.1 Die Sta	acking with TSVs	37
		d Work	38
3		Arithmetic Units	39
4		Chip Multi Vector Processors	42
		verview of 3-D Stacked CMVP	42
_		mance Evaluations	44
5 D		S	47 48
Re	eferences		40
		able Hierarchical Cluster Monitoring	51
Er		Andreas Jeutter	
1	Introduction	1	51
2		ork	52
3		e and Design	52 52
		Design Decisions	52 52
		chy	53 54
1	-	onents	54 5€
4		tionh/Subscribe	56
		ters as Metric Data Publishers	57
	Timpon	tele de l'itelie zana i delibite e ''''''	

Contents ix

	4.3	Subscribers: The Metric Data Consumers
	4.4	Commands via RPC
5	Con	clusion
Re	feren	ces
Pa	rt III	Earthquake Modeling and Simulation on High Performance Computing Systems
Gi	ant E	tion of Vector-Type Super Computer to Understanding arthquakes and Aftershocks on Subduction Plate Boundaries Ariyoshi, Toru Matsuzawa, Yasuo Yabe, Naoyuki Kato,
		ino, Akira Hasegawa, and Yoshiyuki Kaneda
1		oduction
1	1.1	Spatial Distribution of Mega-Thrust Earthquakes
	1.2	Modelling of Coupled Earthquakes
	1.3	Application to Actual Earthquakes
2		nerical Simulation Studies
	2.1	Method of Earthquake-Cycle Simulations
	2.2	A Simulation of Characteristic Slip and Slip Proportional to Fault Size
	2.3	Relation Between Characteristic Slip with Slip
		Proportional to Fault Size
3	Disc	cussion: A Question About the 2011 Tohoku Earthquake
4	Futu	re Megathrust Earthquakes Around Japan
Re	feren	ces
Es	rtha	uake and Tsunami Warning System for Natural
		r Prevention
		Musa, Hiroaki Kuba, and Osamu Kamoshida
1		oduction
2	Eart	hquake Phenomena Observation System (EPOS)
	2.1	Hardware
	2.2	Duplicated Configuration
	2.3	Overview of Issuing Warning
3	EPC	S's Operations on March 11, 2011
	3.1	Earthquake Early Warning
	3.2	Tsunami Warning
	3.3	Enhancement Plan
4		mary
Re	feren	ces

Contents

		oment of Radioactive Contamination Map of ima Nuclear Accident	93	
		Seki, Hiroshi Takemiya, Fumiaki Takahashi, Kimiaki))	
		ei Tanaka, Yutaka Takahashi, Kazuhiro Takemura, and		
		u Tsuzawa		
1			93	
_		Introduction		
2		sground	94 94	
3		ation Monitoring and Mapping	94	
	3.1	Soil Sampling Survey	95	
	3.2	Car-Borne Survey		
	3.3	Air-Borne Survey	95	
4		elopment of the Infrastructure for the Project	96	
	4.1	RMICS	96	
	4.2	KURAMA Data Analysis Software	96	
	4.3	Distribution Map System	97	
	4.4	Distribution Database System	98	
5	Results 9			
	5.1	Distribution Map	99	
	5.2	Distribution of the Ratio	100	
	5.3	Contributions of Dominant Radionuclides to the Total		
		External Effective Dose	101	
	5.4	Car-born Survey Data	103	
6	Sum	mary and Future Plans	103	
So	urce	Process and Broadband Waveform Modeling of 2011		
		Earthquake Using the Earth Simulator	105	
		uboi and Takeshi Nakamura		
1		Tohoku Earthquake	105	
2		hquake Rupture Mechanism	106	
3		adband Synthetic Seismograms	107	
-		ces	111	
,,,	101011			
Pa	rt IV	· r 8 8 11		
		Coupled Multi-physics Simulations		
A :	Fran	nework for the Numerical Simulation of Early Stage		
An	eury	sm Development with the Lattice Boltzmann Method	115	
J. I	3erns	dorf, J. Qi, H. Klimach, and S. Roller		
1		oduction	115	
2		lical Problem and Biological Process	116	
3		ulation Approach	117	
4		ormance Considerations	118	

Contents xi

5	Resu	lts	119
	5.1	Simulation Setup	119
	5.2	Observations	120
	5.3	Discussion	121
6	Conc	clusion and Outlook	121
Re	ferenc	ces	122
Da.		nance Evaluation of a Next-Generation CFD on Various	
		emputing Systems	122
		o Komatsu, Takashi Soga, Ryusuke Egawa, Hiroyuki	123
		a, and Hiroaki Kobayashi	
1 ar			124
_		duction	124
2		rview of the Building Cube Method	124
3	-	ementation of BCM on Various Systems	126
	3.1	Implementation on Scalar Systems	126
	3.2	Implementation on a Vector System	127
	3.3	Implementation on a GPU System	128
4		ormance Evaluation and Discussions	128
5		cluding Remarks	131
Re	ferenc	ces	132
Mo	ortar	Methods for Single- and Multi-Field Applications in	
		tational Mechanics	133
	_	er Popp, Michael W. Gee, and Wolfgang A. Wall	
1		duction	133
2		tar Finite Element Methods	135
3	Aspects of Implementation and High Performance Computing		
_	3.1	Parallel Redistribution and Dynamic Load Balancing	140 140
	3.2	Search Algorithms for Two-Body Contact and Self Contact	144
4		nplary Single-Field and Multi-Field Applications	147
	4.1	Mesh Tying in Solid Mechanics	147
	4.2	Finite Deformation Contact Mechanics	149
	4.3	Fluid-Structure-Contact Interaction (FSCI)	150
	4.4	Large-Scale Simulations	151
5		clusions and Outlook	152
		ces	153
			15.
		Computation for Femtosecond Dynamics in	
Co	nden	sed Matters	155
Yo	shiyu	ki Miyamoto	
1		duction	155
2	The	pretical Backgrounds	156
	2.1	Static Treatment	156
	2.2	Dynamical Treatment	157
	2.3	Simulation with Intense Laser Field	159

xii Contents

3	Ann	lications	161
	3.1		161
	3.2	Pulse Induced Dynamics of Molecules Encapsulated	101
	3.2	Inside Carbon Nanotube	163
4	C		164
•	Some Requirements on High-Performance Computing		
5		mary and Conclusion	166
Re	feren	ces	167
Nı	ımeri	cal Investigation of Nano-Material Processing by	
		Il Plasma Flows	169
1	Iasaya Shigeta Introduction		
2		ry Growth of Functional Nanoparticles	169 171
_	2.1	Model Description	171
			173
	2.2	Computational Conditions	
	2.3	Numerical Results	175
3	Tim	e-Dependent 3-D Simulation of an ICTP Flow	175
	3.1	Model Description	175
	3.2	Computational Conditions	177
	3.3	Numerical Results	178
4	Con	cluding Remarks	180
Re		ces	181