Contents

Preface vii

1 A Concept of Modeling and Optimization of Applications in Large Scale Systems 1
- 1.1 Background . . . 2
- 1.2 Motivations . . . 2
- 1.3 Use Cases . . . 4
- 1.4 Proposed Solution . . . 5
- 1.5 Simulator . . . 9
- 1.6 Optimizer . . . 10
- 1.7 Summary . . . 11

2 Block-based Representation of Application Execution on Modern Parallel Systems 13
- 2.1 Modern Parallel APIs and Systems . . . 14
- 2.2 Important Features in Modern Parallel Systems . . . 15
- 2.3 Existing Application Models . . . 16
- 2.4 Application Model as Pseudocode . . . 17
- 2.5 Representation of Application Execution . . . 18
- 2.6 Examples of Application Execution Representations . . . 22
  - 2.6.1 Parallel Mergesort on a Cluster using C/MPI . . . 22
  - 2.6.2 Parallel Quicksort on a Cluster using C/MPI . . . 22
  - 2.6.3 Parallel Mergesort on a GPU . . . 22
  - 2.6.4 Parallel Mergesort on Multiple GPUs . . . 27
  - 2.6.5 Parallel Mergesort on a CPU and Multiple GPUs . . . 29
  - 2.6.6 Parallel Mergesort on a Cluster with CPUs and Multiple GPUs per Node . . . 30
- 2.7 Summary . . . 31

3 Performance and Electric Power Model for Cluster-grid Processing 35
- 3.1 The Model Assumptions . . . 38
- 3.2 The Empirical Model . . . 38
  - 3.2.1 Computation Block: Integer Processing . . . 38
  - 3.2.2 Communication Block: p2p . . . 40
  - 3.2.3 Communication Block: Broadcast . . . 42
  - 3.2.4 Communication Block: Scatter . . . 43

3.3 Summary and Future Work 44

4 Model of Volunteer Based Systems 47
4.1 Proposed Model 47
4.1.1 Power Consumption Model 48
4.1.2 Communication Model 50
4.1.3 Reliability Model 51
4.2 Model Application to Base Operation Blocks 55
4.2.1 Block O_CPU 55
4.2.2 Block O_GPU 56
4.2.3 Block C_P2P 57
4.2.4 Block C_BCAST / C_MCAST 57
4.2.5 Block C_SCATTER 58
4.2.6 Block C_GATHER 59
4.2.7 Block C_A2A 60
4.2.8 Block C_BARRIER 61
4.2.9 R/W blocks 61
4.3 Summary and Future Work 62

5 Modeling of Performance, Reliability and Energy Efficiency in Large-Scale Computational Environment 63
5.1 Computational Models in Large-Scale 63
5.2 Primary Models of Processing in Complex Systems 64
5.2.1 Sequential Processing 64
5.2.2 Pipelined Processing 65
5.2.3 Parallel Processing 65
5.2.4 Iterative Process 66
5.2.5 Client-Server (or Master-Slave) Processing Model 68
5.2.6 Broadcasting Model of Processing 68
5.3 Selected Quality Attributes of Large-Scale Computations 68
5.3.1 Performance and Time Consumption 69
5.3.2 Reliability 70
5.3.3 Energy Consumption and Power Efficiency 72
5.4 Impact of Computational Configuration on the Quality of Computations . 74
5.4.1 Impact on Performance 74
5.4.2 Impact of the Configuration on Reliability 80
5.4.3 Task Configuration and Power Efficiency 81
5.5 Summary 84

6 Quality Modeling in Grid and Volunteer-Computing Systems 87
6.1 Specific Requirements for Quality Model of Computations in Grid and Volunteer-Computing Systems 87

6.2 Communication Processes in Computation Models 88
6.3 Performance Modeling 89
6.3.1 Operational Performance of Internet User Computer 92
6.4 Reliability Modeling 92
6.4.1 Reliability of Server Processes and Server Availability 93
6.4.2 Computation Reliability of Internet User Computer 94
6.5 Reliability and Performance 95
6.5.1 Impact of Protection Against Attacks on Performance 96
6.6 Energy Consumption Modeling 97
6.6.1 Energy Profit in a Volunteer Computing System 99
6.7 Summary 100

7 Conceptual Design of the Editor Application 103
7.1 Basic Concepts 104
7.2 Definition of a System Modeling Method 104
7.2.1 Explanation of the Modeling Term 104
7.2.2 Overview of System Modeling Tools 105
7.2.3 Tools for System Architecture Modeling 105
7.2.4 Proposed Ways to Define an Application and an Architecture Model 107
7.2.5 Proposition of Components to Facilitate Application Modeling . . 113
7.3 Design of the Application Layout 114
7.3.1 Login Screen 114
7.3.2 Menu Screen 115
7.3.3 Editor Screen 115
7.4 Summary 116

8 Measurement of CPU and GPU Capabilities 121
8.1 Problem Definition 121
8.2 Objectives 122
8.3 Solution 122
8.3.1 Assumed Units 122
8.3.2 Necessary Data 123
8.3.3 Data Sources for Energy Consumption 124
8.3.4 Data Sources for Efficiency 126
8.3.5 Data Sources for Reliability 128
8.3.6 Priorities for Choosing Data Sources 129
8.3.7 Formula for Power Consumption of Central Processing Unit 129
8.3.8 Project of Application Measuring Energy Consumption, Efficiency and Reliability 130
8.4 Example 133
8.4.1 Calculate the Cost of Computation for One Month. 133

8.5 Summary . . . 133

9 Simulation of Parallel Applications on Large Scale Distributed Systems 135
9.1 Formulation of the HPC Simulation Problem . . . 136
9.2 Related Work . . . 139
9.2.1 GridSim . . . 139
9.2.2 MARS Framework . . . 139
9.2.3 CloudSim . . . 140
9.2.4 SimGrid . . . 141
9.2.5 Volunteer Computing Simulation on SimGrid . . . 141
9.2.6 GSSIM . . . 141
9.2.7 SystemC . . . 142
9.3 Proposed Solution . . . 142
9.3.1 Examples of Application Models . . . 143
9.4 Summary and Future Work . . . 145

10 Parallel Computations of Text Similarities for Categorization Task 149
10.1 Experimental Datasets . . . 150
10.2 Clustering Based on Proximity Measures . . . 151
10.2.1 Matrices of Distances and Similarity . . . 151
10.2.2 Parallel Clustering with K-means . . . 154
10.3 Results . . . 158
10.4 Summary and Future Directions . . . 159

11 Some Optimization Methods for Simulations in Volunteer and Grid Systems 161
11.1 Features of the Comcute System . . . 162
11.2 Criteria for a Volunteer System Evaluation . . . 162
11.3 Reliability of a Volunteer and Grid System . . . 164
11.4 A Delay Probability . . . 166
11.5 Bottleneck Node and Limited Capacities of Resources . . . 167
11.6 Evolutionary Approach to Agent Assignment . . . 168
11.7 Some Numerical Experiments . . . 169
11.8 Summary and Concluding Remarks . . . 170

Author Index 173