Hierarchical resource management in grid computing
Korkhov, V.

Citation for published version (APA):
Korkhov, V. V. (2009). Hierarchical resource management in grid computing

General rights
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: http://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.
## Contents

1 Introduction
   1.1 Multi-layered applications on the Grid ................................ 1
   1.2 Hierarchical structure of large-scale distributed applications .... 3
   1.3 Grid architecture hierarchy ............................................. 4
   1.4 Problem solving environments ......................................... 5
   1.5 Thesis outline ............................................................. 7

2 Resource management in Grid computing ................................. 9
   2.1 Issues of Grid resource management ................................... 9
   2.2 Dynamic and transparent workload balancing ....................... 15
   2.3 User-level scheduling .................................................... 17
   2.4 Workflow management ................................................... 18
   2.5 Conclusion and research motivation .................................. 20

3 Multi-layered applications on the Grid: Virtual Reactor Case Study 21
   3.1 Introduction ............................................................... 21
   3.2 Virtual Reactor problem solving environment ....................... 22
      3.2.1 Introducing Virtual Reactor ..................................... 22
      3.2.2 Virtual Reactor application architecture ...................... 23
      3.2.3 Resource infrastructure: Russian-Dutch Grid testbed ......... 27
   3.3 Adaptive workload balancing on heterogeneous resources: theoretical approach ......................................................... 28
      3.3.1 Resource and application parameters ........................... 28
      3.3.2 Adaptive workload balancing algorithm ....................... 29
      3.3.3 Weighting factors and workload distribution .................. 31
   3.4 Performance of the Virtual Reactor on the Grid .................... 33
      3.4.1 Definitions ......................................................... 33
      3.4.2 Speedup of the chemistry-disabled and chemistry-enabled simulations ......................................................... 33
      3.4.3 Computation to communication ratio ............................ 35
      3.4.4 Homogeneous resources: results and discussion ............... 36
      3.4.5 Heterogeneous resources: results and discussion ............. 36
   3.5 Synthetic application and experimental setup ....................... 38
      3.5.1 Load balancing speedup for different applications .......... 39
      3.5.2 Load balancing for master-worker model: heuristic vs. analytical load distribution .............................................. 40
3.6 Conclusions .............................................................. 41

4 Parallel applications in multi-cluster environment: speedup and efficiency on the Grid 43
4.1 Introduction ............................................................ 43
4.2 Speedup and efficiency ............................................... 43
4.3 Parallel applications on a multi-cluster ......................... 45
  4.3.1 Hierarchical decomposition of parallel applications ........ 45
  4.3.2 Grid speedup .................................................. 47
  4.3.3 Limitations and applicability ................................ 49
4.4 Case study: Lattice Boltzmann Method solver on DAS-2 ...... 50
  4.4.1 Strip wise workload decomposition on a homogeneous multi-cluster ........................................ 50
  4.4.2 Estimation of infrastructure parameters .................. 52
  4.4.3 Execution time ............................................... 52
  4.4.4 Grid speedup and efficiency ................................. 54
4.5 Conclusions ............................................................ 58

5 User-level scheduling of multi-job applications 59
5.1 Introduction ............................................................ 59
5.2 Integrated adaptive workload balancing and user-level scheduling environment ......................... 60
  5.2.1 User-level scheduling features .............................. 60
  5.2.2 Executing applications in the user-level scheduling environment on heterogeneous resources .......... 61
  5.2.3 Adaptive load balancing algorithm with resource selection in the user-level scheduling environment .......... 63
  5.2.4 Resource pooling and selection .............................. 66
5.3 DIANE environment for user-level scheduling ................. 67
5.4 Simulation results and discussion ................................. 69
  5.4.1 Adaptive workload balancing and self-scheduling comparison ....................... 69
  5.4.2 Adaptive resource selection ................................ 71
5.5 Conclusions ............................................................ 75

6 Data-driven Workflow Management on the Grid 77
6.1 Introduction ............................................................ 77
6.2 Data-driven workflows in a virtual laboratory ................. 78
6.3 Resource management for data-driven workflows .............. 80
  6.3.1 Workflow modeling ........................................... 80
  6.3.2 Heuristic algorithms for workflow scheduling ........... 82
  6.3.3 Simulation results and discussion .......................... 86
6.4 VLAM-G: interactive data driven workflow management system for the Grid ................................. 87
  6.4.1 The vision ..................................................... 87
  6.4.2 The architecture .............................................. 88