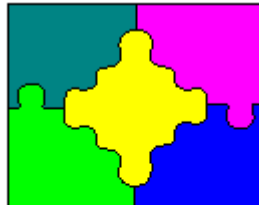# GRID 2000

Grid Computing

The first IEEE/ACM International Workshop on Grid Computing

Bangalore, India, December 17, 2000

Editors:

- **Rajkumar Buyya**

- **Mark Baker**

Preface

Welcome to GRID 2000, the first annual IEEE/ACM international workshop on grid computing sponsored by the IEEE Computer Society's Task Force on Cluster Computing (TFCC) and the Association for Computing Machinery (ACM). The workshop has received generous sponsorship from the European Grid Forum (eGrid), the EuroTools SIG on Metacomputing, Microsoft Research (USA), Sun Microsystems (USA), and the Centre for Development of Advanced Computing (India).

It is a sign of the current high levels of interest and activity in Grid computing that we have had contributions to the workshop from researchers and developers in Australia, Austria, Canada, France, Germany, Greece, India, Italy, Japan, Korea, Netherlands, Spain, Switzerland, UK, and USA. It is our pleasure and honor to present the first annual international Grid computing meeting programme and the proceedings.

The Grid: A new network computing infrastructure

The growing popularity of the Internet along with the availability of powerful computers and high-speed networks as low-cost commodity components are helping to change the way we do computing. These new technologies are enabling the coupling of a wide variety of geographically distributed resources, such as parallel supercomputers, storage systems, data sources, and special devices, that can then be used as a unified resource and thus form what is popularly known as the "Grids". The Grid is analogous to the power (electricity) grid and aims to couple distributed resources and offer consistent and inexpensive access to these resources irrespective of their physical location. The interest in creating Grids (by pooling resources from multiple organizations) is growing due to the potential to solve large-scale problems that cannot be typically solved on local resources. Internationally there are a large number of projects actively exploring the design and development of different Grid system components, services, and applications. Pointers to these projects can be found at the following information sources:

- Grid Infoware – http://www.gridcomputing.com
- IEEE Distributed Systems Online – http://computer.org/channels/ds/gc

It is projected that Grids are expected to drive the economy of the 21st century in a similar fashion to how electrical power grids drove the economy of the 20th century.

Grid systems need to hide complexities associated with the management and usage of resources across multiple administrative institutions. The following are some of the key features of Grid infrastructures:

- Flexibility and extensibility;
- Domain autonomy;
- Scalability;
- Global name space;
- Ease of use and transparent access;

- Performance;
- Security;
- Management and exploitation of heterogeneous resources;
- Interoperability between systems ;
- Resource allocation and co-allocation;
- Fault-tolerance;
- Dynamic adaptability;
- Quality of Service (QoS);
- Computational Economy.

The grid must be designed and created in such a way that their components — fabric, middleware, and higher-level tools — and applications handle the key design issues in a coordinated manner. For instance, Grid middleware offers services for handling heterogeneity, security, information, allocation, and so on. Higher level tools, such as resource brokers support dynamic adaptability through automatic resource discovery, trading for economy of resources, resource acquisition, scheduling, the staging of data and programs, initiating computations, and adapting to changes in the Grid status.. In addition, they also need to make sure that domain autonomy is honored but still meets user requirements such as quality of service (QoS) in coordination with other components. The papers accepted for inclusion in this proceeding address various issues related to the design, development, and implementation of Grid technologies and its applications.

Program Organisation and Acknowledgements

The response to the workshop's call for papers has been excellent and we expect that attendance at the actual workshop will be equally impressive. The GRID 2000 programme consists of a keynote speech (by Wolfgang Gentzsch on "DOT-COMing the GRID: Using Grids for Business"), an invited talk, and refereed technical paper presentations. We have accepted papers from authors of fifteen countries from among submissions from eighteen countries. We would like to thank all authors for submitting their research papers for considerations. We have grouped the contributed papers into five distinct categories, although inevitably there is some overlap:

- Network enabled server systems for the Grid (invited paper)
- Grid resource management
- Grid middleware and problem solving environments
- Grid testbeds and resource discovery
- Application-level scheduling on the Grid

The GRID 2000 meeting would not have taken place without the key efforts of Viktor Prasanna who has been the main driving force behind the international conference on High Performance Computing (HiPC) conference. It is our pleasure to acknowledge his efforts and thank him for encouraging us to organise this annual internal meeting on Grid computing. The success of the workshop is wholly due to the hard work of the programme committee members and external reviewers. They

have donated their precious time for reviewing and offered their expert comments on the papers. All submitted papers have been peer-reviewed by the technical programme committee members and external referees. We have requested four reviews for each paper and ensured that each paper received a minimum of three reviews. All highly recommended and promising works have been selected for presentation at the meeting.

We thank our keynote speaker Wolfgang Gentzsch (Director of Network Computing, Sun Microsystems) and invited speaker Satoshi Matsuoka (Tokyo Institute of Technology, Japan) for presenting their vision on Grid technologies.

We owe a debt of gratitude to all our sponsors and contributors. In particular, we would like thank R.K. Arora (C-DAC, Pune), Mohan Ram (C-DAC, Bangalore), and Wolfgang Gentzsch (Sun Microsystems) for responding to our request for financial support enthusiastically and being instrumental in obtaining generous donations from their respective organisations. Our special thanks go to Todd Needham (Microsoft Research, USA), who has voluntarily come forward to support our Task Force activities. We would also like to thanks Hilda Rivera (ACM) for handling our request for ACM "in-cooperation" status. Finally, we would like to thank the Springer Varlag team, particularly Jan van Leeuwen (LNCS series editor), Alfred Hofmann (Executive Editor), and Antje Endemann. They are wonderful to work with!

We hope these proceedings serve as useful reference on Grid computing. We wish you all the best and hope you enjoy your visit to the Silicon Valley of India!

December 2000
GRID 2000 Co-Chairs
`http://www.gridcomputing.org`

Rajkumar Buyya

Monash University, Australia
http://www.buyya.com

Mark Baker

University of Portsmouth, UK
http://www.dcs.port.ac.uk/~mab/

GRID 2000 Team

Workshop Chairs:

- Rajkumar Buyya, Monash University, Australia.
- Mark Baker, University of Portsmouth, England.

Program Committee Members

- David Abramson, Monash University, Australia.
- Ishfaq Ahmad, The Hong Kong University of Science and Technology.
- David Bader, University of New Mexico, Albuquerque.
- Mark Baker, University of Portsmouth, England.
- Francine Berman, University of California, San Diego.
- Rajkumar Buyya, Monash University, Australia.
- Steve Chapin, Syracuse University, New York.
- Jack Dongarra, University of Tennessee/ORNL, Knoxville.
- Wolfgang Gentzsch, Sun Microsystems, USA.
- Jonathan Giddy, Distributed Systems Technology Centre, Australia.
- Sergi Girona, Universitat Politecnica de Catalunya, Spain.
- Ken Hawick, Adelaide University, Australia.
- Hai Jin, University of Southern California, Los Angeles.
- William Johnston, Lawrence Berkeley National Lab. / NASA Ames., USA
- Vipin Kumar, University of Minnesota, Minneapolis.
- Domenico Laforenza, CNUCE (Inst. of Italian National Research Council)
- Gregor von Laszewski, Argonne National Laboratory, Chicago.
- Craig Lee, The Aerospace Corporation, Los Angeles.
- Miron Livny, University of Wisconsin, Madison.
- Muthucumaru Maheswaran, University of Manitoba, Canada.
- Satoshi Matsuoka, Tokyo Institute of Technology, Japan.
- Jarek Nabrzyski, Poznan Supercomputing and Networking Center, Poland.
- Lalit Patnaik, Indian Institute of Science, Bangalore.
- Mohan Ram, Centre for Development of Advanced Computing, Bangalore.
- Alexander Reinefeld, ZIB, Berlin, Germany.
- Michael Resch, High Performance Computing Center Stuttgart, Germany.
- Les Robertson, European Organization for Nuclear Research, Switzerland.
- Mitsuhisa Sato, Real World Computing Partnership, Japan.
- Peter Sloot, University of Amsterdam, Netherlands.

GRID 2000 Additional Referees

We acknowledge the following external referees for reviewing papers (the list does not include members of the program committee, who did most of the review work):

- Achim Streit
- Antonio Lagana
- Arthur Maccabe
- Daniele Micciancio
- Dick van Albada
- Franck Cappello
- Gerd Quecke
- Heath James
- Heinz Stockinger
- Henri Casanova
- John Brooke
- Kirk Schloegel
- Mihir Bellare
- Mike Ashworth
- Omer F. Rana
- Paul Coddington
- Rafael Avila
- Spyros Lalis
- Vishwanath P. Baligar
- Walfredo Cirne
- William Leinberger
- Wolfgang Ziegler
- Yuzhong Sun

GRID 2000 Sponsors and Supporters

Institute of Electrical and Electronics Engineers (IEEE) http://www.ieee.org	
IEEE Computer Society http://www.computer.org	
IEEE Task Force on Cluster Computing (TFCC) http://www.ieeetfcc.org	
Association for Computing Machinery (ACM SIGARCH) http://www.acm.org	
EuroTools SIG on Metacomputing http://www.eurotools.org/	
European Grid Forum (eGRID) http://www.egrid.org/	
Centre for Development of Advanced Computing (C-DAC), India http://www.cdacindia.com/	
Microsoft Research, USA http://www.research.microsoft.com	
Gridware Inc., Germany/USA. http://www.gridware.com	

Table of Contents

Grid Test-Beds and Resource Discovery

Application-level Scheduling on the Grid