

**Cloud Computing and Distributed Systems Laboratory
and the Cloudbus Project**



Annual Report - 2009



Department of Computer Science and Software Engineering

Melbourne School of Engineering

The University of Melbourne, Australia

1. Director's Message

I am pleased to report on the key activities and outcomes of **Cloud Computing and Distributed Systems (CLOUDS) Laboratory** at the University of Melbourne, Australia during the academic year 2009, which has been an extraordinary year in terms of productivity and international recognition of its members. The Lab's R&D activities have rapidly grown in the area of Cloud computing and the Lab has emerged as one of the world-leaders in developing innovative solutions for Cloud Computing. The highlights of research activities and outcomes in 2009 are:



- The Lab successfully completed two large research projects: (i) ARC (Australian Research Council) Discovery Project “QoS-based Scheduling of e-Research Application Workflows on Global Grids” and (ii) DIISR International Science Linkage (ISL) project on “Autonomic and Utility-oriented Global Grids for Powering Emerging E-Research Applications” connecting Australian researchers those in USA, Europe, India, and China.
- The Lab successfully transferred IP of Aneka software technology to its spin-off company, Manjrasoft, which has released Aneka 1.0 software and filed an international Patent (PCT) application.
- Members of CLOUDS Lab have authored 57 publications, which include 2 books, 13 journal papers, and 27 conference papers.
- The Lab's flagship Cloudbus Project has released “open source” CloudSim 1.0 Toolkit, which is used by several researchers in academia and industries around the world.
- Members have presented over 32 invited talks that include 7 keynotes delivered at international conferences held in Germany, Australia, China, India, and Brazil.
- The Lab successfully hosted research activities of over 24 scholars: 12 PhD students, 10 Research Fellows (8 at PostDoc level and 2 Software Engineers), and couple of Masters/honours students. Three Ph.D students have graduated.
- The Lab Director and many of its members have been recognised for their outstanding contribution to the field of distributed computing by awards such as “2009 IEEE Medal for Excellence in Scalable Computing” and Microsoft Research Fellowship.
- The Lab housed several (short and long term) international visitors (academic and PhD students) from USA, Spain, India, Malaysia, and Brazil.
- Received “2009 Outstanding Paper Award” from IEEE Communications Society, USA.
- Received “Best Paper Award” from the 32nd Australasian Computer Science Conference (ACSC 2009, Wellington, New Zealand), Jan. 2009.
- Published a text book on “Object Oriented Programming with Java: Essentials and Applications (McGraw Hill, India) and an edited book on “Market Oriented Grid and Utility Computing” (Wiley, USA).
- Members of the Lab have led community efforts by (a) involving in the organisation of conferences (e.g., ICPP 2009 in Vienna, Austria), (b) served on the Steering Committee of 5 international conferences and (c) served as the Chair of the Advisory Board of the IEEE Technical Committee on Scalable Computing.

The Lab is always looking for talented, motivated, and dedicated “young” students and researchers to join its team. Please feel free to contact me with your ideas!

Professor Rajkumar Buyya, PhD
Director, Cloud Computing and Distributed Systems (CLOUDS) Laboratory
Department of Computer Science and Software Engineering
The University of Melbourne, Australia
Web : cloudbus.org

2. The Team

Director:

- Professor Rajkumar Buyya

Research Staff:

- Dr. Srikumar Venugopal
- Dr. Chao Jin
- Dr. James Broberg
- Mr. Xingchen Chu
- Dr. Christian Vecchiola
- Dr. Alexandre di Costanzo
- Dr. Rajiv Ranjan
- Dr. Chee Shin Yeo
- Mr. Dileban Karunamoorthy
- Dr. Adam Barker

PhD Students

- Mr. Marcos Assunção
- Mr. Marco Netto
- Mr. Mukaddim Pathan
- Mr. Mustafizur Rahman
- Mr. Saurabh Garg
- Mr. Suraj Pandey
- Mr. William Voorsluys
- Ms. Charity Laplap
- Mr. Mohsen Amini
- Mr. Amir Vahid
- Mr. Anton Beloglazov
- Ms. Linlin Wu

Masters by Research Students

- Mr. Michael Mattess

Collaborators

- Colleagues holding research grants with the Director
 - International Visitors
 - Many collaborators involved in extending and using the Cloudbus software.
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3. Competitive Grants Funded Projects and Programs

Australian Research Council (ARC)

- R. Buyya, QoS-based Scheduling of e-Research Application Workflows on Global Grids, Discovery Project, Australian Research Council, Australia, 2007-2009. Amount: \$319,000.
- R. Buyya, A Novel Software System for .NET-based Enterprise Grid Computing, Linkage Project, Australian Research Council (ARC) and Microsoft Corporation, Australia, 2007-2010. Amount: \$395,000 (ARC: \$265,000 and Microsoft: \$130,000).
- J. Broberg and Z. Tari, Coordinated and Cooperative Load Sharing between Content Delivery Networks, Discovery Project, Australian Research Council (ARC), Australia, 2008-2010. Amount: \$315,000
- R. Buyya and J. Abawajy, InterGrid: Peering Architecture and Policies for Internetworking Disparate Grids, Discovery Project, Australian Research Council (ARC), Australia, 2008-2010. Amount: \$216,000.
- R. Buyya, Service Level Agreement (SLA) oriented Resource Allocation for Data Centers and Cloud Computing Systems, Linkage Project, Australian Research Council (ARC), Australia and CA (Computer Associates), Australia, 2009-2011. Amount: \$273,000 (ARC: \$195,000 and CA: \$78,000).

Commonwealth of Australia - CRC (Cooperative Research Centre) Grant

- R. Buyya (project manager) and team, *The Utility Grid Project: Autonomic and Utility-oriented Global Grids for Powering Emerging E-Research Applications*, International Science Linkages, Department of Education, Science & Training, Australia, 2006-2009. Amount: \$592,875.

European Union Projects Grant:

- R. Buyya was part of a team and the University of Melbourne as an international partner in an European Union funded project led by Prof. Denis Caromel (INRIA, France), "Grids Programming with Components (GridComp), 2006-2009. Amount: € 1,928,278.00.

4. Publications

- The Lab publication record since its inception in 2002 highlighted in the Table below:

Publication Type \ Year	2002	2003	2004	2005	2006	2007	2008	2009
Books/Proceedings Edited	1	1	1	1	5	4	3	5
Journal Papers	6	1	4	5	6	4	10	13
Book Chapters	1	0	0	4	4	2	4	11
Conference Papers	4	7	9	16	15	24	22	27
Magazine/Other Articles	0	0	1	2	4	2	0	1
<i>Total</i>	12	9	15	28	34	36	39	57

Books

- Rajkumar Buyya, Thamarai Selvi, Xingchen Chu, Object Oriented Programming with Java: Essentials and Applications, ISBN 978-0-07066-908-6, Tata McGraw Hill Press, New Delhi, India, 2009.
- Rajkumar Buyya and Kris Bubendorfer (eds.), Market Oriented Grid and Utility Computing, 643 pages, ISBN: 9780470287682, Wiley Press, New York, USA, 2009.

Book Chapters

- Xingchen Chu, Srikumar Venugopal, and Rajkumar Buyya, Grid Resource Broker for Scheduling Component-based Applications on Distributed Resources, Cyberinfrastructure Technologies and Applications, J. Cao (ed), ISBN: 978-1-60692-063-3, Nova Science Publishers, Hauppauge NY, USA, 2009.
- Jia Yu and Rajkumar Buyya, Gridbus Workflow Enactment Engine, Grid Computing: Infrastructure, Service, and Applications, 119-146pp, L. Wang, W. Jie, and J. Chen (eds), ISBN: 978-1420067668, CRC Press, Boca Raton, FL, USA, April 2009.
- James Broberg and Rajkumar Buyya, Flow Networking in Grid Simulations, Grid Computing: Infrastructure, Service, and Applications, 389-404pp, L. Wang, W. Jie, and J. Chen (eds), ISBN: 978-1420067668, CRC Press, Boca Raton, FL, USA, April 2009.
- Uros Cibej, Anthony Sulistio and Rajkumar Buyya, Grid Computing, Parallel Computing: Numerics, Applications, and Trends, R. Trobec, M. Vajtersic, P. Zinterhof (eds), ISBN: 978-1-84882-408-9, Springer-Verlag, London, UK, July 2009.
- Rajiv Ranjan and Rajkumar Buyya, Decentralized Overlay for Federation of Enterprise Clouds, Handbook of Research on Scalable Computing Technologies, K.C. Li, C. H. Hsu, L. T. Yang, J. Dongarra, and H. Zima, ISBN: 978-1-60566-661-7, IGI Global, Hershey, PA, USA, July 2009.
- Marcos Dias de Assuncao and Rajkumar Buyya, Architectural Elements of Resource Sharing Networks, Handbook of Research on Scalable Computing Technologies, K.C. Li, C. H. Hsu, L. T. Yang, J. Dongarra, and H. Zima, ISBN: 978-1-60566-661-7, IGI Global, Hershey, PA, USA, July 2009.
- Rajkumar Buyya and Srikumar Venugopal, Market Oriented Computing and Global Grids: An Introduction, Market Oriented Grid and Utility Computing, R. Buyya and K. Bubendorfer (eds), ISBN: 978-0470287682, Wiley Press, Hoboken, New Jersey, USA, Oct. 2009.
- Rajkumar Buyya and David Abramson, The Nimrod/G Grid Resource Broker for Economic-based Scheduling, Market Oriented Grid and Utility Computing, R. Buyya and K. Bubendorfer (eds), ISBN: 978-0470287682, Wiley Press, Hoboken, New Jersey, USA, Oct. 2009.

9. Jia Yu, Kotagiri Ramamohanarao, and Rajkumar Buyya, Deadline and Budget based Scheduling of Workflows on Utility Grids, Market Oriented Grid and Utility Computing, R. Buyya and K. Bubendorfer (eds), ISBN: 978-0470287682, Wiley Press, Hoboken, New Jersey, USA, Oct. 2009.
10. Rajkumar Buyya, Srikumar Venugopal, Rajiv Ranjan, and Chee Shin Yeo, The Gridbus Middleware for Market-Oriented Computing, Market Oriented Grid and Utility Computing, R. Buyya and K. Bubendorfer (eds), ISBN: 978-0470287682, Wiley Press, Hoboken, New Jersey, USA, Oct. 2009.
11. Christian Vecchiola, Xingchen Chu, and Rajkumar Buyya, Aneka: A Software Platform for .NET-based Cloud Computing, High Speed and Large Scale Scientific Computing, 267-295pp, W. Gentzsch, L. Grandinetti, G. Joubert (Eds.), ISBN: 978-1-60750-073-5, IOS Press, Amsterdam, Netherlands, 2009.

Proceedings Edited

1. Franck Cappello, Cho-Li Wang, and Rajkumar Buyya, Proceedings of the 9th IEEE International Symposium on Cluster Computing and the Grid (CCGrid 2009, Shanghai, China), ISBN 978-0-7695-3622-4, IEEE CS Press, Los Alamitos, CA, USA.
2. Jorn Altmann, Rajkumar Buyya, Omer Rana, Proceedings of the 6th International Workshop on Grid Economics and Business Models (GECON 2009, Delft, The Netherlands, August 24, 2009), LNCS 5745, ISBN: 978-3-642-03863-1, Springer, Berlin, Germany.
3. Sanjay Ranka, Srinivas Aluru, Rajkumar Buyya, Yeh-Ching Chung, Sandeep Gupta, Ananth Grama, Rajeev Kumar, Vir V. Phoha, and Sumeet Dua, Second International Conference on Contemporary Computing (IC3 2009, Noida, India, August 17-19, 2009), ISBN: 978-3-642-03546-3, Springer, Berlin, Germany.

Journal Papers

1. Anthony Sulistio, Uros Cibej, Sushil Prasad, and Rajkumar Buyya, GarQ: An Efficient Scheduling Data Structure for Advance Reservations of Grid Resources, International Journal of Parallel, Emergent and Distributed Systems, Volume 24, Number 1, Pages: 1-19, ISSN: 1744-5760, Taylor & Francis Publication, UK, Jan. 2009.
2. Marcos Dias de Assuncao and Rajkumar Buyya, Performance Analysis of Allocation Policies for InterGrid Resource Provisioning, Information and Software Technology Journal, Volume 51, Number 1, Pages: 42-55, ISSN: 0950-5849, Elsevier Science, Amsterdam, The Netherlands, Jan. 2009.
3. Chee Shin Yeo and Rajkumar Buyya, Integrated Risk Analysis for a Commercial Computing Service in Utility Computing, Journal of Grid Computing, Volume 7, Number 1, Pages: 1-24, ISSN: 1570-7873, Springer, Germany, March 2009.
4. Hui Li and Rajkumar Buyya, Model-based Simulation and Performance Evaluation of Grid Scheduling Strategies, Future Generation Computer Systems, Volume 25, Number 4, Pages: 460-465, ISSN: 0167-739X, Elsevier Science, Amsterdam, The Netherlands, April 2009.
5. Rajkumar Buyya, Chee Shin Yeo, Srikumar Venugopal, James Broberg, and Ivona Brandic, Cloud Computing and Emerging IT Platforms: Vision, Hype, and Reality for Delivering Computing as the 5th Utility, Future Generation Computer Systems, Volume 25, Number 6, Pages: 599-616, ISSN: 0167-739X, Elsevier Science, Amsterdam, The Netherlands, June 2009.
6. Peter J. Harris, Rajkumar Buyya, Xingchen Chu, Tom Kobialka, Ed Kazmierczak, Robert Moss, William Appelbe, Peter J. Hunter, and S. Randall Thomas, The Virtual Kidney: an e-Science Interface and Grid Portal, Philosophical Transactions of the Royal Society A, Volume 367, Issue 1896, Pages: 2141-2159, ISSN 1364-503X, The Royal Society, London, UK, June 2009.

7. Mukaddim Pathan and Rajkumar Buyya, Architecture and Performance Models for QoS-Driven Effective Peering of Content Delivery Networks, Multiagent and Grid Systems, Volume 5, Number 2, Pages: 165-195, ISSN: 1574-1702, IOS Press, Amsterdam, The Netherlands, July 2009.
8. Khaled Talukder, Michael Kirley and Rajkumar Buyya, Multiobjective Differential Evolution for Scheduling Workflow Applications on Global Grids, Concurrency and Computation: Practice and Experience, Volume 21, Number 13, Pages: 1742-1756, ISSN: 1532-0626, Wiley Press, New York, USA, August 2009.
9. Mukaddim Pathan and Rajkumar Buyya, Resource Discovery and Request-Redirection for Dynamic Load Sharing in Multi-Provider Peering Content Delivery Networks, Journal of Network and Computer Applications, Volume 24, Number 1, Pages: 976-990, ISSN: 1084-8045, Elsevier, Amsterdam, The Netherlands, Sept. 2009.
10. James Broberg, Rajkumar Buyya, and Zahir Tari, "MetaCDN: Harnessing 'Storage Clouds' for High Performance Content Delivery", Journal of Network and Computer Applications, Volume 32, Number 5, Pages: 1012-1022, ISSN: 1084-8045, Elsevier, Amsterdam, The Netherlands, Sept. 2009.
11. Alexandre di Costanzo, Marcos Dias de Assuncao, and Rajkumar Buyya, Harnessing Cloud Technologies for a Virtualized Distributed Computing Infrastructure, IEEE Internet Computing, Volume 13, Number 5, Pages: 24-33, ISSN: 1089-7801, IEEE Computer Society Press, Los Alamitos, CA, USA, September/October 2009.
12. Suraj Pandey, William Voorsluys, Mustafizur Rahman, Rajkumar Buyya, James Dobson, and Kenneth Chiu, A Grid Workflow Environment for Brain Imaging Analysis on Distributed Systems, Concurrency and Computation: Practice and Experience, Volume 21, Number 16, Pages: 2118-2139, ISSN: 1532-0626, Wiley Press, New York, USA, November 2009.
13. Balachandar R. Amarnath, Thamarai Selvi Somasundaram, Mahendran Ellappan, and Rajkumar Buyya, Ontology-based Grid Resource Management, Software: Practice and Experience (SPE), Volume 39, Number 17, Pages: 1419 - 1438, ISSN: 0038-0644, Wiley Press, New York, USA, Dec. 10, 2009.

Magazine Papers

1. Dexter Duncan, Xingchen Chu, Christian Vecchiola, and Rajkumar Buyya, The Structure of the New IT Frontier: Cloud Computing, Strategic Facilities Magazine, Pacific & Strategic Holdings Pte Ltd, Singapore, Issue 9, August/September 2009.

Conference Papers

1. Saurabh Garg, Rajkumar Buyya and Howard J. Siegel, [Scheduling Parallel Applications on Utility Grids: Time and Cost Trade-off Management](#), Proceedings of the 32nd Australasian Computer Science Conference (ACSC 2009), ISBN 978-1-920682-72-9, Australian Computer Society, January 19-23, 2009, Wellington, New Zealand. - **Best Paper Award**.
2. Christian Vecchiola, Michael Kirley, and Rajkumar Buyya, [Multi-Objective Problem Solving With Offspring on Enterprise Clouds](#), Proceedings of the 10th International Conference on High-Performance Computing in Asia-Pacific Region (HPC Asia 2009), March 2~5, 2009, Kaohsiung, Taiwan.
3. Xingchen Chu, Rajkumar Buyya, Enric Tejedor, Rosa Badia, [A Novel Approach for Realising Superscalar Programming Model on Global Grids](#), Proceedings of the 10th International Conference on High-Performance Computing in Asia-Pacific Region (HPC Asia 2009), March 2-5, 2009, Kaohsiung, Taiwan.
4. Saman Taghavi Zargar, M. Amir Moulavi, Rajkumar Buyya, Mahmoud Naghibzadeh, James B. D. Joshi, [RRNA: reliable soft real-time network aware grid scheduling algorithm](#)

- [using round trip time](#), Proceedings of the 12th Communications and Networking Simulation Symposium (CNS'09), March 22-27, 2009, San Diego, CA, USA.
5. Xiaofeng Wang, Rajkumar Buyya, and Jinshu Su, [Reliability-Oriented Genetic Algorithm for Workflow Applications Using Max-Min Strategy](#), Proceedings of the 9th IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGrid 2009), Shanghai, China, May 18-21, 2009.
 6. Khaled Talukder, Michael Kirley and Rajkumar Buyya, [The Pareto-Following Variation Operator as An Alternative Approximation Method and Analysis on Its Applicability Issues](#), IEEE Congress on Evolutionary Computation (CEC 2009), Trondheim, Norway, May 18-21, 2009. **Best Student Paper Award Nominee.**
 7. Marco Netto and Rajkumar Buyya, [Offer-based Scheduling of Deadline-Constrained Bag-of-Tasks Applications for Utility Computing Systems](#), Proceedings of the 18th International Heterogeneity in Computing Workshop (HCW 2009), in conjunction with the 23rd IEEE International Parallel and Distributed Processing Symposium (IPDPS 2009), Roma, Italy, May 25, 2009.
 8. Suraj Pandey, William Voorsluys, Mustafizur Rahman, Rajkumar Buyya, James Dobson, and Kenneth Chiu, [Brain Image Registration Analysis Workflow for fMRI Studies on Global Grids](#), Proceedings of the 23rd IEEE International Conference on Advanced Information Networking and Applications (AINA 2009), Bradford, UK, May 26-29, 2009.
 9. Xiaofeng Wang, Chee Shin Yeo, Rajkumar Buyya, and Jinshu Su, [Reliability-Driven Reputation Based Scheduling for Public-Resource Computing Using GA](#), Proceeding of the 23rd IEEE International Conference on Advanced Information Networking and Applications (AINA 2009), Bradford, UK, May 26-29, 2009.
 10. Cory Henson, Holger Neuhaus, Amit Sheth, Krishnaprasad Thirunarayan, Rajkumar Buyya, [An Ontological Representation of Time Series Observations on the Semantic Sensor Web](#), Proceedings of 1st International Workshop on the Semantic Sensor Web 2009, collocated with the 6th European Semantic Web Conference (ESWC 2009), Herkalion, Greece, June 1, 2009.
 11. Marcos Dias de Assuncao, Alexandre di Costanzo and Rajkumar Buyya, [Evaluating the Cost-Benefit of Using Cloud Computing to Extend the Capacity of Clusters](#), Proceedings of the 18th International Symposium on High Performance Distributed Computing (HPDC 2009, ACM Press, New York, USA), Munich, Germany, June 11-13, 2009.
 12. Rajkumar Buyya, Rajiv Ranjan and Rodrigo N. Calheiros, [Modeling and Simulation of Scalable Cloud Computing Environments and the CloudSim Toolkit: Challenges and Opportunities](#), Proceedings of the 7th High Performance Computing and Simulation Conference (HPCS 2009, ISBN: 978-1-4244-4907-1, IEEE Press, New York, USA), Leipzig, Germany, June 21 - 24, 2009. - **Keynote Paper.**
 13. Rodrigo N. Calheiros, Everton Alexandre, Andrielle B. do Carmo, Cesar A. F. De Rose, Rajkumar Buyya, [Towards Self-Managed Adaptive Emulation of Grid Environments](#), Proceedings of the 14th IEEE Symposium on Computers and Communications (ISCC 2009, IEEE Press, New Jersey, USA), Sousse, Tunisia, Jul 5-8, 2009.
 14. Arun Anandasivam, Stefan Buschek and Rajkumar Buyya, [Bid Price Control for Pricing Services in Clouds](#), Proceedings of the 11th IEEE Conference on Commerce and Enterprise Computing (CEC 2009), Vienna, Austria, July 20-23, 2009.
 15. Chao Jin and Rajkumar Buyya, [MapReduce Programming Model for .NET-based Cloud Computing](#), Proceedings of the 15th International European Parallel Computing Conference (EuroPar 2009, LNCS, Springer, Berlin, Germany), Delft, The Netherlands, Aug. 25-28, 2009.
 16. Rodrigo N. Calheiros, Rajkumar Buyya, and Cesar A. F. De Rose, [A Heuristic for Mapping Virtual Machines and Links in Emulation Testbeds](#), Proceedings of the 38th International Conference on Parallel Processing (ICPP 2009, IEEE CS Press, USA), Vienna, Austria, September 22-25, 2009.
 17. Mukaddim Pathan, James Broberg, and Rajkumar Buyya, [Maximizing Utility for Content Delivery Clouds](#), Proceedings of the 10th International Conference on Web Information Systems Engineering (WISE 2009), Poznan, Poland, October 5-7, 2009.

18. Mustafizur Rahman, Rajiv Ranjan, Rajkumar Buyya, [Dependable Workflow Scheduling in Global Grids](#), Proceedings of the 10th IEEE International Conference on Grid Computing (Grid 2009), Banff, Alberta, Canada, October 13-15, 2009.
19. Mukaddim Pathan and Rajkumar Buyya, [Content-Serving Utility of Multi-Provider Peering Content Delivery Networks](#), Proceedings of the 34th IEEE Conference on Local Computer Networks (LCN 2009), Zurich, Switzerland, October 20-23, 2009.
20. Chao Jin and Rajkumar Buyya, [An Adaptive Mechanism for Fair Sharing of Storage Resources](#), Proceedings of the 21st International Symposium on Computer Architecture and High Performance Computing (SBAC-PAD 2009), Sao Paulo, Brazil, October 28-31, 2009.
21. Kyong Hoon Kim, Anton Beloglazov, and Rajkumar Buyya, [Power-aware Provisioning of Cloud Resources for Real-time Services](#), Proceedings of the 7th International Workshop on Middleware for Grids, Clouds and e-Science (MGC 2009), ACM Press, Urbana Champaign, Illinois, USA, Dec. 1, 2009.
22. William Voorsluys, James Broberg, Srikumar Venugopal and Rajkumar Buyya, [Cost of Virtual Machine Live Migration in Clouds: A Performance Evaluation](#), Proceedings of the 1st International Conference on Cloud Computing (CloudCom 2009, Springer, Germany), Beijing, China, December 1-4, 2009.
23. Rajkumar Buyya, Suraj Pandey, and Christian Vecchiola, [Cloudbus Toolkit for Market-Oriented Cloud Computing](#), Proceeding of the 1st International Conference on Cloud Computing (CloudCom 2009, Springer, Germany), Beijing, China, December 1-4, 2009. - **Keynote Paper.**
24. Alexandre di Costanzo, Chao Jin, Carlos A. Varela, and Rajkumar Buyya, [Enabling Computational Steering with an Asynchronous-Iterative Computation Framework](#), Proceedings of the 5th IEEE International Conference on e-Science, Oxford, U.K., December 2009.
25. Christian Vecchiola, Suraj Pandey, and Rajkumar Buyya, [High-Performance Cloud Computing: A View of Scientific Applications](#), Proceedings of the 10th International Symposium on Pervasive Systems, Algorithms and Networks (I-SPAN 2009, IEEE CS Press, USA), Kaohsiung, Taiwan, December 14-16, 2009. - **Keynote Paper.**
26. Saurabh kumar Garg and Rajkumar Buyya, [Exploiting Heterogeneity in Grid Computing for Energy-Efficient Resource Allocation](#), Proceedings of the 17th International Conference on Advanced Computing and Communications (ADCOM 2009), Bengaluru, India, Dec. 14-18, 2009.
27. Srikumar Venugopal, James Broberg, and Rajkumar Buyya, [OpenPEX: An Open Provisioning and EXecution System for Virtual Machines](#), Proceedings of the 17th International Conference on Advanced Computing and Communications (ADCOM 2009), Bengaluru, India, Dec. 14-18, 2009.

5. Invited Presentations and Outreach

By the Lab Director:

Keynote Talks at International Conferences

1. Market-Oriented Cloud Computing: Vision, Hype, and Reality of Delivering Computing as the 5th Utility, 9th IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGrid 2009), May 18-21, 2009, Shanghai, China.
2. Market-Oriented Cloud Computing: Vision, Hype, and Reality of Delivering Computing as the 5th Utility, The 2009 High Performance Computing & Simulation (HPCS'09) Conference / The International Wireless Communications and Mobile Computing Conference (IWCMC 2009), June 21 - 24, 2009, Leipzig, Germany.
3. Cloud Computing, 4th ChinaGrid Annual Conference (ChinaGrid 2009), Yantai, Shandong, China, August 21-22, 2009.
4. Cloud Computing: Vision, Hype, and Reality, Marcus-Evans Conference on Cloud Computing, Sydney, Oct. 8-9, 2009, Sydney, Australia.
5. **Panel Talk:** Cloud Computing - Research Challenges and Opportunities, 21st International Symposium on Computer Architecture and High Performance Computing (SBA-PAD 2009), Sao Paulo, Brazil, October 28-31, 2009.
6. Market-Oriented Cloud Computing, The 1st International Conference on Cloud Computing (CloudCom 2009), Beijing, China, Dec. 1-4, 2009.
7. High Performance Cloud Computing, The 10th International Symposium on Pervasive Systems, Algorithms and Networks, Kaohsiung, Taiwan, December 14-16, 2009.
8. Cloud Computing: The Next Revolution in Information Technology, International Conference on Advanced Computing (ICAC 2009), Chennai, India, Dec. 13-15, 2009.

Seminars - in Cloud Computing area:

1. Advanced Data Processing Research Institute (ADRIN), Indian Space Research Organisation (ISRO), Hyderabad, India, Jan. 6, 2009.
2. Centre for Development of Advanced Computing (C-DAC), Hyderabad, India, Jan. 7, 2009.
3. University of Sydney, Australia, April 8, 2009.
4. Swinburne University, Melbourne, Australia, April 17, 2009.
5. Flinders University, Adelaide, Australia, June 10, 2009.
6. The University of Adelaide, Australia, June 12, 2009.
7. Chemnitz University of Technology, Chemnitz, Germany, June 19, 2009.
8. Infocomm Development Authority of Singapore (IDA), Singapore, June 26, 2009.
9. National University of Singapore, Singapore, June 26, 2009.
10. Shanghai Supercomputer Center, Shanghai, China, Aug. 19, 2009.
11. Shanghai Jiao Tong University (SJTU), Shanghai, China, Aug. 20, 2009.
12. Infosys Technologies Limited, Bangaluru, India, Aug. 25, 2009.
13. Vel Tech University, Chennai, India, Aug. 26, 2009.
14. HCL Technologies Limited, Chennai, India, Aug. 26, 2009.
15. RMIT University, Melbourne, Australia, Sept. 25, 2009.
16. University of New South Wales (UNSW), Sydney, Australia, Oct. 9, 2009.
17. Kasetsart University, Bangkok, Thailand, Nov. 30, 2009.
18. Beijing Jiaotong University, Beijing, China, Dec. 7, 2009.
19. Tsinghua University, Beijing, China, Dec. 8, 2009.
20. Chinese Academy of Sciences, Beijing, China, Dec. 9, 2009.
21. Chinese Academy of Sciences, ShenZhen/Dongguan, China, Dec. 10, 2009.
22. Industrial Technology Research Institute (ITRI), Hsinchu, Taiwan, Dec. 11, 2009.

23. National Center for High-Performance Computing, Hsinchu, Taiwan, Dec. 11, 2009.
24. Anna University, Chennai, India, Dec. 15, 2009.
25. MAM College of Engineering/Anna University, Trichy, India, Dec. 16, 2009.
26. RNS Institute of Technology, Bangalore, India, Dec. 18, 2009.
27. MSR Institute of Technology, Bangalore, India, Dec. 19, 2009.
28. C-DAC (Center for Development of Advanced Computing), Hyderabad, India, Dec. 28, 2009.
29. Guru Nanak Dev Engineering College, Bidar, India, Dec. 30, 2009.

Conference Tutorials

1. Market-Oriented Cloud and Grid Computing, 10th International Conference on High-Performance Computing in Asia-Pacific Region (HPC Asia 2009), March 2~5, 2009, Kaohsiung, Taiwan.
2. Market-Oriented Grid Computing and the Gridbus Middleware, 9th IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGrid 2009), May 18-21, 2009, Shanghai, China.
3. Market-Oriented Grid Computing and the Gridbus Middleware, The 2009 High Performance Computing and Simulation (HPCS 2009) Conference, June 21 - 24, 2009, Leipzig, Germany.
4. Cloud Computing: Vision, Tools, and Technologies for Delivering Computing as the 5th Utility, 21st International Symposium on Computer Architecture and High Performance Computing, Oct. 28-31, 2009, Sao Paulo, Brazil.
5. Cloud Computing: The Next Revolution in Information Technology, 17th International Conference on Advanced Computing and Communications (ADCOM 2009), Bengaluru, Dec. 14-17, 2009.

By Other Members:

Conference Tutorials and Seminars

1. C. Vecchiola (with R. Buyya), Market-Oriented Cloud and Grid Computing, 10th International Conference on High-Performance Computing in Asia-Pacific Region (HPC Asia 2009), March 2~5, 2009, Kaohsiung, Taiwan.
2. C. Vecchiola, Aneka: A .Net Cloud Computing Platform, Department of Computing, Hong Kong Polytechnic University, Hong Kong, China, March 7, 2009.
3. J. Broberg, MetaCDN: Enabling High Performance, Low Cost Content Storage and Delivery via the Cloud, RMIT University, April 17, 2010.
4. J. Broberg, Introduction to Cloud Computing, 9th IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGrid 2009), May 18-21, 2009, Shanghai, China.

6. Selected Community Services

By the Lab Director:

IEEE Computer Society

1. Chair of Advisory Board, IEEE Technical Committee on Scalable Computing

Journal Editorials

1. Associate Editor, *Future Generation Computer Systems (FGCS)* -- The International Journal of Grid Computing: Theory, Methods and Applications, ISSN: 0167-739X, Elsevier Press, Amsterdam, The Netherlands.
2. Editorial Board Member, *International Journal of Parallel, Emergent and Distributed Systems (IJPEDS)*, ISSN: 1744-5760, Taylor & Francis Group, UK.
3. Editorial Board Member, *International Journal of Web Services Research*, ISSN: 1545-7362, Idea Group Publications, USA, 2003 onwards.
4. Editorial Board Member, *International Journal of Grid and Utility Computing*, ISSN: 1741-847X, Inderscience Publishers, Geneva, Switzerland, 2004 onwards.
5. Editorial Board Member, *Multiagent and Grid Systems: An International Journal*, ISSN: 1574-1702, IOS Press, Amsterdam, The Netherlands, 2005 onwards.
6. Editorial Board Member, *Software: Practice and Experience*, ISSN: 0038-0644, Wiley Press, New York, USA, 2009-to date.

Conference Steering Committee

1. Chair, CCGrid conference series: IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGrid): CCGrid 2001, Brisbane, Australia; CCGrid 2002, Berlin, Germany; CCGrid 2003, Tokyo, Japan; CCGrid 2004 in Chicago, USA; CCGrid 2005, UK; CCGrid 2006, Singapore; CCGrid 2007, Brazil; CCGrid 2008, Lyon, France, and CCGrid 2009, Shanghai, China.
2. Co-Chair, International Conference on e-Science(e-Science) series, 2005- to date.
3. Member, IEEE International Conference on Cluster Computing (ClusterXY), 1999-to date.
4. Member, International Symposium on Computer Architecture and High Performance Computing, Brazil, 2005-to date.
5. Member, IEEE/ACM International Conference on Grid Computing (GRIDxy), 2000-to date.

Conference Chair

1. PC Vice Chair, 38th International Conference on Parallel Processing (ICPP-2009), September 22-25, 2009, Vienna, Austria.
2. Co-Chair, 6th International Workshop on Grid Economics and Business Models (GECON 2009), August 24, 2009, Delft, The Netherlands.

Misc. Services Chair

1. Publications Chair, 9th IEEE International Symposium on Cluster Computing and the Grid (CCGrid 2009), May 18-21, 2009, Shanghai, China.

Technical Program Committee Memberships

1. 17th International Conference on Advanced Computing and Communications (ADCOM 2009), Dec. 14-18, 2009, Bangalore, India.
2. 5th IEEE International Conference on e-Science, Dec.7-9, 2009, Oxford, UK.
3. 2009 IEEE Asia-Pacific Services Computing Conference (IEEE APSCC 2009), December 7-11, 2009, Singapore.
4. 11th International Symposium on Stabilization, Safety, and Security of Distributed Systems (SSS 2009), Nov. 3-6, 2009, Lyon, France.
5. 11th International Conference on Electronic commerce (ICEC 2009), Aug. 12-15, 2009, Taipei, Taiwan.
6. 11th IEEE International Conference on High Performance Computing and Communications (HPCC 2009), June 25-27, 2009, Seoul, Korea.
7. 23rd IEEE International Conference on Advanced Information Networking and Applications (AINA 2009), May 26-29, 2009, Bradford, UK.
8. 18th International Heterogeneity in Computing Workshop (HCW 2009), May 25, 2009, Rome, Italy.
9. 9th IEEE International Symposium on Cluster Computing and the Grid (CCGrid 2009), May 18-21, 2009, Shanghai, China.
10. 10th International Conference and Exhibition on High-Performance Computing in Asia-Pacific Region (HPC Asia 2009), Kaohsiung, Taiwan.

Community Information Sources

- Maintained a Grid Computing Information Centre at: <http://www.gridcomputing.com>, whose newsletter mailing list has over 2400 members. This website is often ranked as #2 source for grid computing by Google search engine.
- Maintained a Cluster Computing Information Centre at: <http://www.buyya.com/cluster>

By Other Members:

Workshops Chair

1. J. Broberg (with R. Buyya), International Workshop on Cloud Computing (Cloud 2009), In Conjunction with 9th IEEE International Symposium on Cluster Computing and the Grid (CCGrid 2009), May 18-21, 2009, Shanghai, China.

Technical Program Committee Memberships

1. Srikumar Venugopal, 17th International Conference on Advanced Computing and Communications (ADCOM 2009), Dec. 14-18, 2009, Bangalore, India.
2. James Broberg, ADCOM 2009 Conference, Dec. 14-18, 2009, Bangalore, India.
3. Mukaddim Pathan, 2009 International Workshop on Frontier of Secure Networks (IFSN 2009), Shanghai, China, 17-19 December, 2009.
4. Rajiv Ranjan, ADCOM 2009 Conference, Dec. 14-18, 2009, Bangalore, India.

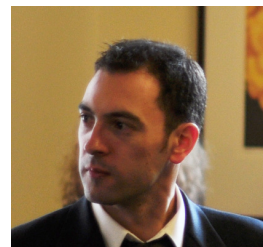
7. International Visiting Researchers

1. Cory Andrew Henson, Wright State University, USA, Jan-March 2009.
 2. Arun Anandasivam, Universität Karlsruhe, Germany, Jan-March 2009.
 3. Professor Carlos A. Varela, Rensselaer Polytechnic Institute, USA, Jan-Aug 2009.
 4. Alberto Sánchez-Campos, Universidad Rey Juan Carlos, Madrid, Spain, May-Aug 2009.
 5. Rodrigo N. Calheiros, Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, Brazil, Aug 2008-2009.
 6. Nithiapidary Muthuvelu, Multimedia University, Malaysia, Jun-Dec, 2009 - on Australian DIISR Fellowship.
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8. Continuing Members Profile and Activities

Member Self Profile: Dr. Christian Vecchiola

I am part of the CLOUDS Lab since 2008 when I joined as a Postdoctoral Research Fellow working on Distributed Evolutionary Computation and Global Grids. I completed my Ph.D. at the University of Genova, Italy with a thesis on “*Providing Support for Evolvable System: An Agent-based Approach*”. My research now is mostly focused on tools and technologies for Cloud Computing and development of Platform as a Service solution frameworks and solutions for distributed computing applications over the Cloud. Besides research I also teach the Distributed Computing subject and co-teach the Cluster and Grid Computing subject in my department.



Genetic algorithms are compute intensive and time consuming optimization algorithms that can be applied to different real life scenarios such as airfoil dynamic design, protein structure prediction, and virtually any problem that can be characterized by a single or multi-objective function that needs to be optimized. As part of my research in distributed evolutionary computation I have provided support for distributed execution of evolutionary algorithms, initially on Grids and then on Clouds. I have also developed a software prototype – called Offspring – for helping research scientists in quickly prototype distributed implementations of evolutionary algorithms. Such a prototype leverages Aneka, which has been my major development and software design effort since I joined the group.

Cloud Computing is an interesting new opportunity for companies to leverage on demand third parties for IT infrastructure, services, and applications. It allows to dynamically provision virtual hardware, scale applications according to their needs and integrate new services to existing application. The scenario envisioned by Cloud Computing poses new interesting challenges ranging from infrastructure management, quality of service, application management and scheduling, and dynamic provisioning. Platform as a Service (PaaS) solutions provide a scalable and elastic middleware for executing applications on the Cloud, provides the right venue where to experiment many of the aspects introduced before. As part of my research I have strongly contributed to the development of Aneka, which integrates Cloud Computing capabilities such as Quality of Service based execution and dynamic provisioning.

In 2010, I will deepen my research on the models and the technologies that enable Cloud Computing and make it an available resource for everyone. In particular I will focus on how dynamic provisioning can profitably support the execution of distributed applications and allow the creation of Hybrid Clouds.

C. Vecchiola, X. Chu, M. Mattess, and R. Buyya, *Aneka - Integration of Private and Public Clouds*, Cloud Computing Principles and Paradigms, R. Buyya, J. Broberg, A.Goscinski (eds), ISBN-13: 978-0470887998, Wiley Press, New York, USA, 2010. (in press, accepted on Dec. 10, 2009).

C. Vecchiola, S. Pandey, and R. Buyya, *High Performance Cloud Computing: A View of Scientific Applications*, Proceedings of the 10th International Symposium on Pervasive Systems, Algorithms, and Networks (I-SPAN 2009), December 14-16, 2009, Kaohsiung, Taiwan.

R. Buyya, S. Pandey, and C. Vecchiola, *Cloudbus Toolkit for Market-Oriented Cloud Computing*, Proceeding of the 1st International Conference on Cloud Computing (CloudCom 2009, Springer, Germany), December 1-4, 2009, Beijing, China.

C. Vecchiola, M. Kirley, and R. Buyya, *Multi-Objective Problem Solving With Offspring on Enterprise Clouds*, Proceedings of the 10th International Conference on High-Performance Computing in Asia-Pacific Region (HPC Asia 2009), March 2-5, 2009, Kaohsiung, Taiwan.

C. Vecchiola, X. Chu, and R. Buyya, *Aneka: A Software Platform for .NET-based Cloud Computing*, High Speed and Large Scale Scientific Computing, 267-295pp, W. Gentsch, L. Grandinetti, G. Joubert (Eds.), ISBN: 978-1-60750-073-5, IOS Press, Amsterdam, Netherlands, 2009.

Member Self Profile: Saurabh Kumar Garg

I am a PhD student under the supervision of Dr. Rajkumar Buyya in Cloud Computing and Distributed Systems (CLOUDS) Laboratory of The University of Melbourne. I started my candidature in August 2007. I completed my 5-year Integrated Master of Technology in Mathematics and Computing from the Indian Institute of Technology (IIT) Delhi, India, in 2006. After completing my post graduate degree, I joined the IBM Indian Research Laboratory Delhi, where I worked in the area of High Performance Computing. I designed and optimized the FFT and Random Access benchmarks for Blue Gene/L, which is the fastest supercomputer from IBM. Here in Melbourne University, I has been awarded with various scholarships such as Nicta-Topup Scholarship, MIFRS, and MIRS for my PhD candidature.



After joining GRIDS Laboratory, I studied various research works in the field of Grid computing. Thus, I studied utility computing, market principles in grid computing, SLA based resource allocation, workflow, data grids etc. This study not only gave me a strong foundation in the area but also gave me insight for some of the open problems. I developed my expertise in simulation modelling particularly in Grid Simulation Toolkits such as GridSim, CloudSim and Gridbus Broker. I also developed a simple design of meta-broker while working on Gridbus Broker.

During my PhD, I developed various market- and SLA-based policies for meta-broker which will map multiple resources to multiple Cloud consumers to achieve the balance in demand and supply, improve the throughput while maximizing the utilities of Cloud consumers and providers. I also examined the problem of contention at a resource by introducing a third party meta-broker which allocates resources to users in a coordinated manner. Currently I am working in the area of green and cloud computing to provision resources based on SLAs and energy consumption of infrastructure.

I have proposed various meta-scheduling policies^{1, 2, 3} to solve this problem. These works received recognition both at national and International level and thus received three best paper awards. I am also awarded with the DreamLarge Knowledge Transfer Project Grant with my other colleagues for the project, entitled, "Knowledge Transfer of Next-Generation Grid Technologies to Empower Emerging Economies"⁴. These grants are awarded to appreciate and encourage the qualities of leadership, project management, and interdisciplinary collaboration.

¹**Garg S. K., Buyya R., and Siegel H. J., "Scheduling ParallelApplications on Utility Grids: Time and Cost Trade-off Management," Australasian Computer Science Conference (ACSC2009), cosponsors: Australian Computer Society and New Zealand Computer Society, Wellington, New Zealand, Jan. 2009. (Received "**Best Paper**" and "**Best Student Paper**" Award).**

² (*)**Garg S. K. and Buyya R., "Exploiting Heterogeneity in Grid Computing for Energy-Efficient Resource Allocation", The 17th International Conference on Advanced Computing and Communications (ADCOM 2009), Bengaluru, India, Dec., 2009.**

³ (*)**Garg S. K., Buyya R., and Siegel H. J., "Time and Cost Trade-off Management for Scheduling Parallel Applications on Utility Grids," Future Generation Computer Systems, Volume 26, Number 8, Pages: 1344-1355, 2009. (ARC ERA Tier = A)**

⁴<http://www.gridbus.org/cdn/ktp/>

Member Self Profile: William Voorsluys

I joined the CLOUDS Lab in February 2008, when I started my PhD studies in the University of Melbourne.

In the past few years, before coming to Melbourne, I've been involved with aspects of grid and cloud computing, virtualization technologies and load balancing in distributed systems. This interest started back in the year 2000 during my undergraduate studies, when I developed load-balancing algorithms for heterogeneous clusters. Later, in my master's research in the University of Sao Paulo, I've studied memory-related metrics that allow a precise evaluation of a system's memory-usage, with the objective of aiding cluster load balancing policies to make better decisions.



From 2005 to 2008 I have worked as a researcher in the OurGrid project, a Brazilian grid computing initiative, which is dedicated to research and development of a peer-to-peer grid computing solution.

My PhD research aims at creating a provisioning and allocation mechanism for virtualised data centres. A key feature of my research is the concept of workload mobility. I'm leveraging live migration of virtual machines to achieve load balancing and fault tolerance capabilities.

More specifically, my research involves devising a mechanism that uses detailed information about resource utilization in each virtual machine to intelligently consolidate and redistribute the workload in a datacenter.

My main achievements in 2009 included: confirmation of my PhD candidature by a committee of advisors; publication of a journal paper in *Concurrency and Computation, Practice and Experience*¹; publication of a research paper at the CloudCom 2009 conference²; and writing a survey in Cloud Computing technologies, which is due to be published as a book chapter in 2010³.

I was also pleased to have been awarded a Microsoft Research Fellowship to further support my PhD studies, generously provided by MSRA, Beijing, China.

¹ Suraj Pandey, William Voorsluys, Mustafizur Rahman, Rajkumar Buyya, James Dobson, and Kenneth Chiu, **A Grid Workflow Environment for Brain Imaging Analysis on Distributed Systems**, *Concurrency and Computation: Practice and Experience*, Volume 21 Issue 16, 2009. ISSN: 1532-0626, Wiley Press, New York, USA. DOI: 10.1002/cpe.1461

² William Voorsluys, James Broberg, Srikumar Venugopal, and Rajkumar Buyya. **Cost of Virtual Machine Live Migration in Clouds: A Performance Evaluation**. In: *Proceedings 1st International Conference on Cloud Computing* (CloudCom 2009, LNCS 5931, Springer, Berlin, Germany), Beijing, China. December 2009.

³ William Voorsluys, James Broberg, and Rajkumar Buyya, **Introduction to Cloud Computing**, *Cloud Computing: Principles and Paradigms*, R. Buyya, J. Broberg, A.Goscinski (eds), ISBN-13: 978-0470887998, Wiley Press, New York, USA, 2010. (in press, accepted on Dec. 10, 2009).

Member Self Profile: Anton V. Beloglazov

I am Anton V. Beloglazov, I am from Novosibirsk, Russian Federation. I am a second year PhD candidate under the supervision of Prof. Rajkumar Buyya at the Cloud Computing and Distributed Systems (CLOUDS) Laboratory within the Department of Computer Science and Software Engineering, The University of Melbourne, Australia. I have joined the CLOUDS Lab in 2009 to pursue my PhD studies funded by Endeavour International Postgraduate Research Scholarship and Melbourne International Research Scholarship. Prior to my PhD, I have graduated from Novosibirsk State Technical University in 2006 with Bachelor's degree followed by Master's degree in 2008 in Computer Science and Engineering.



My PhD research topic is "Energy and performance efficient resource management in virtualized data centers for Cloud computing". My current work is done under the Green Cloud Computing Project, <http://cloudbus.org/greencloud/>. It is focused on policies and algorithms for continuous consolidation of virtual machines in virtualized Cloud data centers in order to minimize energy consumption, while maintaining the required Quality of Service. I have contributed to the development of CloudSim, a modern open-source framework for modeling and simulation of Cloud computing infrastructures and services (<http://www.cloudbus.org/cloudsim/>). Apart from contributing to the core framework, I have developed extensions allowing simulations of dynamic workloads and power-aware resource allocation.

In 2009 I have also worked on a taxonomy and survey of energy-efficient data centers and Cloud computing systems. The taxonomy discusses major research challenges in energy-efficient resource management and covers for main management levels: hardware and firmware, operating system, virtualization and data center levels. In 2009 my research work on energy-efficient dynamic consolidation of virtual machines has resulted in the following publications:

1. Beloglazov, and R. Buyya, "Energy Efficient Allocation of Virtual Machines in Cloud Data Centers," In Proceedings of the 10th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid 2010), accepted in 2009.
2. Beloglazov, and R. Buyya, "Energy Efficient Resource Management in Virtualized Cloud Data Centers," IEEE TCSC Doctoral Symposium, In Proceedings of the 10th IEEE/ACM International Symposium on Cluster, Cloud, and Grid Computing (CCGrid 2010), accepted in 2009.
3. Beloglazov, R. Buyya, "Power and Performance Efficient Resource Management in Cloud Computing," In Proceedings of IEEE Science and Engineering Graduate Research Expo 2009, Melbourne, Australia, 2009, pp. 38-40.
4. K.H. Kim, A. Beloglazov, and R. Buyya, "Power-aware Provisioning of Cloud Resources for Real-time Services," In Proceedings of the 7th International Workshop on Middleware for Grids, Clouds and e-Science, Urbana Champaign, Illinois, USA: ACM, 2009.

For the full list of publications and details of my past and current work, please visit my web-page: <http://beloglazov.info/>

Visiting Member Self Profile: Rodrigo N. Calheiros

I am Rodrigo N. Calheiros. I'm from Porto Alegre, Rio Grande do Sul, Brazil. I am a PhD candidate in the Pontifical Catholic University of Rio Grande do Sul (PUCRS), where I'm current in the last year of my course. Since August 2008, I've been worked in the CLOUDS lab as a visiting student, where I'm staying for one year. My visit is sponsored by the Brazilian government, through the CAPES PDEE scholarship program (aka "sandwich" PhD). My Brazilian supervisor is Professor César A. F. De Rose.



Before starting my PhD, I got a Degree in Computer Engineering by Federal University of Rio Grande (FURG) and a MSc. Degree in Computer Science by PUCRS (also supervised by Prof. De Rose). The research topic in my masters thesis was resource scheduling in Grid Computing¹, specially for the case of allocating idle cycles of clusters for executing grid applications. My masters was funded by Hewlett-Packard Brazil R&D.

My PhD search is on virtualization technology and its application in distributed systems emulation^{2,3}, and it was also a partnership with HP Brazil R&D. Since I joined the Lab, I've been working in the CloudSim project, originally developed as a tool to support simulation scenarios required by my thesis topic. Since then, it has grown to become a tool to support research in the emerging Cloud Computing area. We are working to increase CloudSim's users base to make this tool as successful as GridSim.

My current research interest areas include Resource Management in Clouds and Grids, Simulation, Emulation, and Virtualization.

1. R. N. Calheiros, T. Ferreto, and C. D. Rose. Scheduling and management of virtual resources in grid sites: the Site Resource Scheduler. *Parallel Processing Letters*, 19(3):3-18, 2009.
2. R. N. Calheiros, M. Storch, E. Alexandre, C. A. F. De Rose, and M. Breda. *Applying virtualization and system management in a cluster to implement an automated emulation testbed for grid applications*. In 20th International Symposium on Computer Architecture and High Performance Computing SBAC-PAD, 2008.
3. R. N. Calheiros, E. Alexandre, A. B. do Carmo, C. A. F. De Rose, and R. Buyya. *Towards self-managed adaptive emulation of grid environments*. In IEEE Symposium on Computers and Communications (ISCC), 2009.

Member Self Profile: Mohsen Amini Salehi

I am Mohsen Amini Salehi, I have a Bachelor (2003) and Master degree (2005) in Computer Science, from Azad University of Mashhad and Ferdowsi University of Mashhad, Iran respectively. Currently I am a second year PhD student at the University of Melbourne, Australia. My main research interests are resource provisioning in resource sharing environments such as InterGrid and Combining Grid and Cloud computing resources.



In 2004, when I was still an undergraduate, I started to get interest on research management and scheduling. In that year, I joined a new research centre on high performance computing (Simorgh), in Computer center of Ferdowsi University. During the period of 2003-2005, I worked with resource management and load balancing in Grid computing under supervision of Dr. Hossein Deldari. In that period I developed tools, wrote research papers, and patents. In 2005, I moved back to Azad University of Mashhad as a faculty member and lecturer. Since 2005 up to 2008 I was teaching in Azad University of Mashhad in Operating System Concepts and Computer Networks. As a researcher I was working on Text Summarization Systems during that period and I could get a research grant on that area.

In 2008, I joined CLOUDS Lab, at the University of Melbourne, Australia, to pursue my PhD under supervision of Dr. Rajkumar Buyya. My research has been focused on resource provisioning in InterGrid, which extends my background in Master degree. However, different from my previous research, at this time I am considering environments which support lease-based resource provisioning. My thesis is on scheduling of requests with different priority and different level of SLA needed.

In 2009, I worked with the scheduling of Bag-of-Tasks applications on local resources that can be extended to cloud resources. I proposed market-oriented scheduling policies, namely time-optimization and cost-optimization, along with considering other user constraints such as deadline and budget. I extended Gridbus Broker to be able to lease resources from Amazon EC2 (as a Cloud provider) and applied the proposed policies in Gridbus broker context. The paper published based on this research work got accepted in ICA3PP 2010 conference in Busan, South Korea. I attended the conference and present the paper there. Moreover, the research idea proposed and implemented got 3rd rank in IEEE Expo 2009, Melbourne.

I have also worked on providing resources for local users in InterGrid where there are different types of user requests. More specifically, we consider two major types of user requests namely, local users' requests and Grid users' requests. However, Grid users' should be preempted in the case that there are not enough resources for coming local requests.

I am currently working on a scheduling policy in InterGrid Gateway (IGG) level. This scheduling policy schedules user requests on different sites of a Grid in a way that the minimum number of preemption occurs.

For the list of publications and details about my past and current work, please visit my webpage: <http://www.csse.unimelb.edu.au/~mohsena>

Member Self Profile: Suraj Pandey

I am a PhD student in my 3rd year at the CLOUDS lab. My supervisor is Prof. Rajkumar Buyya.

My core research focuses on **Scheduling and Management of Data Intensive Applications on Clouds**. The year 2009 has been very productive for me.

I have been able to publish my research and development activities in journals and conferences.



Software Demonstrations:

1. [Second IEEE International Scalable Computing Challenge \(SCALE 2009\)](#) in conjunction with the 9th IEEE International Symposium on Cluster Computing and the Grid (CCGrid 2009), Shanghai - China / May 18-21, 2009. **Second Prize Winners**
2. [Summit 09 Cloud Challenge](#) in conjunction with [Summit 09: Partnerships in CI Development](#), Banff, Alberta, Canada, Oct 12 - 16, 2009.

Journal Papers:

1. **Suraj Pandey**, William Voorsluys, Mustafizur Rahman, Rajkumar Buyya, James Dobson, Kenneth Chiu, [A Grid Workflow Environment for Brain Imaging Analysis on Distributed Systems](#). Concurrency and Computation: Practice and Experience, Volume 21, Number 16, Pages: 2118-2139, ISSN: 1532-0626, Wiley Press, New York, USA, November 2009.

Conference Papers:

1. Rajkumar Buyya, **Suraj Pandey**, Christian Vecchiola, [Cloudbus Toolkit for Market-Oriented Cloud Computing](#), Proceeding of the 1st International Conference on Cloud Computing (CloudCom 2009, Springer, Germany), Beijing, China, December 1-4, 2009.
2. Christian Vecchiola, **Suraj Pandey**, and Rajkumar Buyya, [High-Performance Cloud Computing: A View of Scientific Applications](#), Proceedings of the 10th International Symposium on Pervasive Systems, Algorithms and Networks (I-SPAN 2009, IEEE CS Press, USA), Kaohsiung, Taiwan, December 14-16, 2009.
3. **Suraj Pandey**, William Voorsluys, Mustafizur Rahman, Rajkumar Buyya, James Dobson, Kenneth Chiu, [Brain Image Registration Analysis Workflow for fMRI Studies on Global Grids](#). In Proceedings of the 23rd IEEE International Conference on Advanced Information Networking and Applications (AINA-09), Bradford, UK, May 2009

Short Papers/Posters/Magazines:

1. Suraj Pandey, Dileban Karunamoorthy, Kapil Kumar Gupta, Rajkumar Buyya, [Megha Workflow Management System for Application Workflows](#), In IEEE Science & Engineering Graduate Research Expo 2009, Melbourne, Australia, 2009.

Student Project+Thesis Supervisions

1. Dileban Karunamoorthy, [Gridbus Workflow Management System and Aneka Enterprise Middleware A project on the integration of the two technologies](#), Masters of Engineering in Distributed Computing Project, University of Melbourne, June 2009.

Member Self Profile: Dileban Karunamoorthy

I joined CLOUDS Lab in August 2009 in the capacity of a Research Fellow contributing primarily to the on-going research and development of a platform for building cloud applications. Aneka, one of the flagship projects in the research group, is an infrastructure for developing cloud-based applications capable of utilizing resources on the desktop, clusters, and on-demand resources from infrastructure-as-a-service providers.

Prior to joining CLOUDS Lab I was pursuing a course in Engineering, focusing on Distributed Computing (MEDC). In the fall of 2008, after finishing my first semester at University of Melbourne, I began working as a part-time Research Assistant with the CLOUDS Lab group. My primary contribution, until the end of semester one in 2009, was towards integrating Aneka with the Cloudbus Workflow Management System. This work also led to my Master's thesis, supervised by Dr. Rajkumar Buyya. The integration involved developing plugins and Web Services to translate and communicate jobs from the workflow engine into a form that can be readily consumed by Aneka. This also required extending the Aneka platform to support transferring files from remote locations. This work also presented me with a good opportunity to deepen my knowledge and understanding of grid and cloud computing and the technologies that enable them.



Since August 2009, I began working on a license management system for Aneka. This was an important feature in the commercialization process for Aneka through Manjrasoft Pty Ltd., a spin-off company of the University of Melbourne. The licensing system provides facilities for enforcing a restricted installation of the platform. I also developed a system to support the dynamic discovery of specific types of nodes and services in an Aneka deployment. This system will serve the basis for fault-tolerance (to be developed later) resulting in more resilient environment in the event some of the services become unavailable. Other areas that I worked on include security, file transfers and management tools. Towards the end of 2009 I was largely involved in the release of Aneka 1.0. This involved rigorous testing, fixing all known issues, documenting, and packing Aneka for its first major release.

With cloud computing gaining wide adoption in the industry, features such as fault-tolerance, security, monitoring, reporting and billing become crucial. In 2010 I will focus my efforts on researching and developing services and tools to support these features in Aneka.

Suraj Pandey, Dileban Karunamoorthy and Rajkumar Buyya, Workflow Engine for Clouds, Cloud Computing: Principles and Paradigms, R. Buyya, J. Broberg, A.Goscinski (eds), ISBN-13: 978-0470887998, Wiley Press, New York, USA, 2010. (in press, accepted on Dec. 10, 2009)

9. Selected Projects/Programs

Cloudbus: A Toolkit for Market-Oriented Cloud Computing

Web: <http://www.cloudbus.org/>

The Cloud Computing and Distributed Systems (CLOUDS) Laboratory is a software research and innovation group at the University of Melbourne, Australia. The Lab is actively engaged in design and development of next-generation computing systems and applications that aggregate by dynamically leasing services of distributed resources depending on their availability, capability, performance, cost, and users' QoS requirements. The lab is working towards realising this vision through its two flagship projects: Gridbus and Cloudbus.

The Cloudbus project, an initiative that started in 2008 by the CLOUDS lab at the University of Melbourne, facilitates the realization of the above vision. The project developed innovative solutions for market-oriented Cloud computing. The current innovative developments include: (i) Aneka, a platform for developing and managing Cloud computing applications from market-oriented perspective; (ii) InterCloud, a framework for internetworking of Cloud service providers, dynamically creating federated computing environments, and scaling of distributed applications; (iii) CloudSim, a simulation framework that allows researchers to control every aspect of a Cloud environment: algorithms, platforms, and infrastructure; and (iv) Workflow Engine, a management platform that facilitates the creation, deployment and monitoring of complex applications modeled in a systematic and orderly manner in Cloud computing environments.

The CLOUDbus project

The Cloudbus project is engaged in the creation of open-source specifications, architecture and a reference Cloud toolkit implementation of market-oriented cloud computing. Some of our technologies serve as foundation for industrial solutions offered by Manjrasoft to its customers worldwide.

The research probes include:

- Market Oriented Cloud Architecture
- Enterprise Cloud Application Platform (Aneka)
- Cloud Service Broker
- Cloud Workflows and Scheduling
- Service Level Agreements & Resource Allocation Systems (Libra).
- Energy-Efficient Data Centers and Clouds
- Cloud Simulation Toolkit (CloudSim).
- Application Development Environments
- Application Targets include: ECG Monitoring and Analysis, Data Mining and Business Analytics, Brain Imaging (Dartmouth Medical School), and Geophysics (*Intrepid*).
- Open SensorWeb Architecture
- InterCloud – Peering and Federation of Clouds
- Content Delivery Networks

Gridbus: Middleware for Utility-based Grid Computing

Web: <http://www.gridbus.org/>

An Inaugural Knowledge Transfer Award Winning Project at the University of Melbourne

One of the flagship projects of the Cloud Computing and Distributed Systems (CLOUDS) Laboratory is the Gridbus Project which covers various research sub-projects that look into the management of distributed resources and scheduling of applications on global Grids. The Gridbus Project is unique in that it explores the practical application of well-known economic theories to solve resource management problems in Grids. In addition to fundamental R&D, the Gridbus Project has also partnered with various scientific, engineering, and business communities in applying Grid technologies to solve various challenging problems in e-Science and e-Business domains. The Gridbus Project has advanced the discipline of Grid computing in the following ways:

- Carried out fundamental research in distributed resource management and application scheduling on global Grids.
- Pioneered the principles of Grid economy as well as techniques and mechanisms that enable the delivery of Grid services as utility-like services.
- Proposed several adaptive scheduling algorithms for deploying applications on global Grids based on users' quality of service (QoS) requirements.
- Co-developed fundamental Grid technologies that enable the creation of scalable Grid environments as well as support the rapid development of Grid-enabled applications.
- Applied Grid technologies to several applications in collaboration with domain scientists, and deployed them both on national and international Grid infrastructure.

The research probes include:

- Service-Oriented Grid Architecture
- Grid Economy and Resource Management.
- Grid Service Broker
- .NET based Enterprise Grid Framework (Aneka)
- Grid Workflows and Scheduling
- Service Level Agreements (SLA)-based Resource Allocation Systems (Libra).
- Grid Simulation Toolkit (GridSim).
- Resource Usage Accounting (GridBank).
- Grid Application Development Environment
- Open SensorWeb Architecture.
- InterGrid for peering and internetworking between islands of Grids
- Application Targets: Drug Discovery (*WEHI*), Neuroscience (HFI & *Osaka Uni*), Kidney Modelling, Natural Language Processing, High-Energy Physics, Catchment Hydrology (eWater CRC), and Financial Investment Risk & Portfolio Analysis (*Spain*).

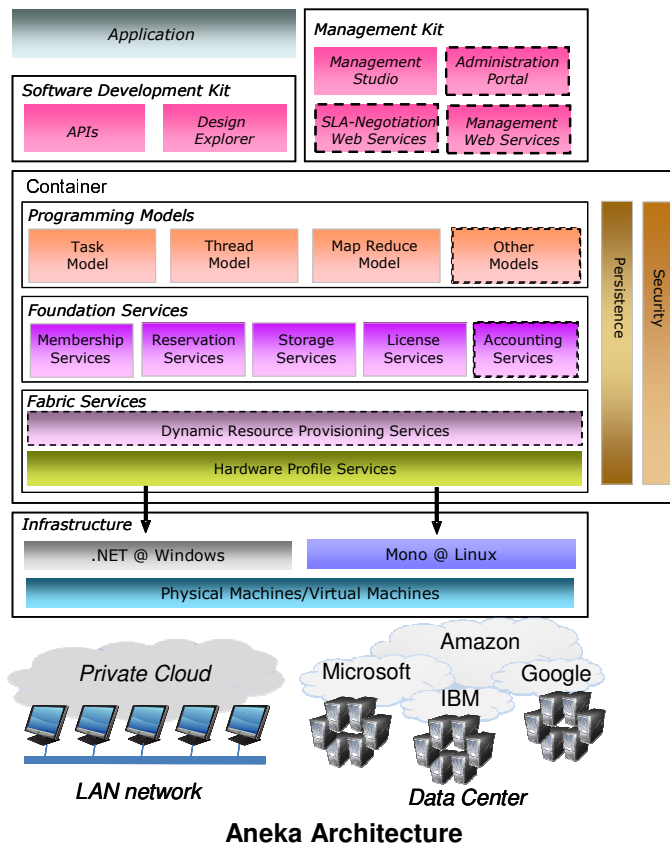
The software developed as part of the Gridbus Project has been released as open source which enables practitioners around the world to benefit from the products of the Grid research carried out at the University of Melbourne. The Grid software technologies developed by the Gridbus Project such as Gridbus Broker, GridSim, and Alchemi have helped a broad range of people, from research students and established academics to industrial practitioners in institutions and enterprises around the world. Other activities such as training of students on real Grid projects, and tutorials and seminars in conferences around the world have produced benefits both in Australia and around the world. Therefore, by developing, sharing and teaching fundamental Grid technologies, the project has been able to make immense impact on scientific, engineering, and business communities around the world. Recently, the project received a large International Science Linkage (ISL) grant from the Commonwealth DEST to establish strategic research linkages with international projects based in Europe, USA, and Asia.

Aneka: .NET-based Cloud Computing

Web: <http://www.manjrasoft.com>

ANEKA provides a set of services that make construction and development of Clouds and their applications as easy as possible without sacrificing flexibility, scalability, reliability and extensibility. It is now commercialized through Manjrasoft, a startup company of the University of Melbourne. The key features supported by ANEKA are:

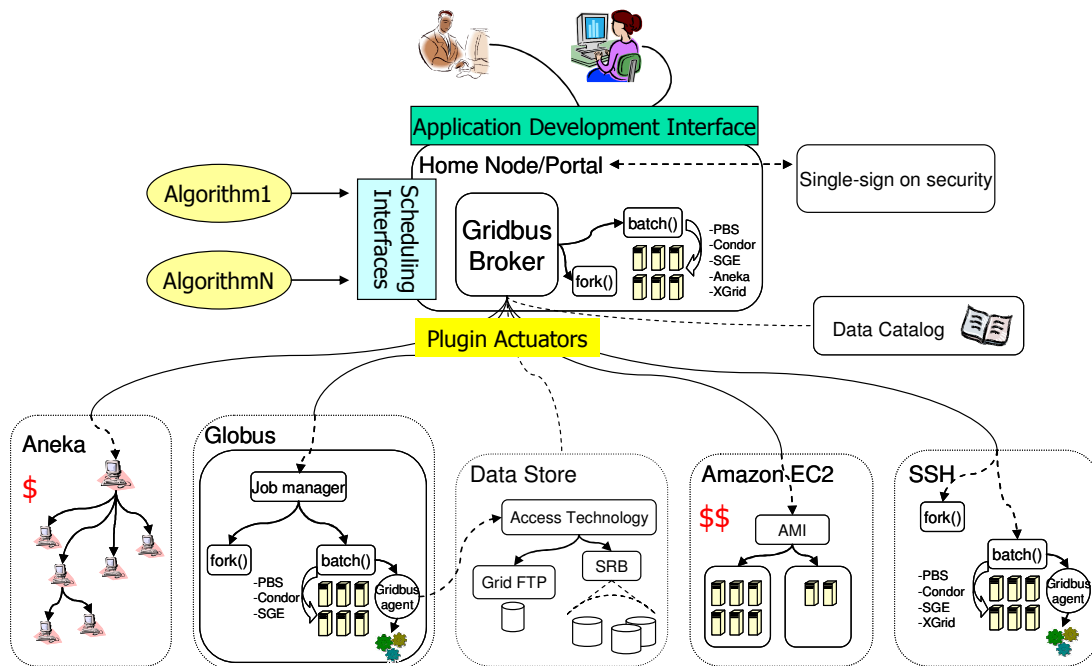
- A configurable and flexible execution platform (container) enabling -
 - pluggable services;
 - security implementations - multiple authentication / authorisation mechanisms such as role-based security and Windows domain-based authentication;
 - multiple persistence options including RDBMS, SQL Express, MySQL and flat files;
- SDK (Software Development Kit) supporting multiple programming models including –
 - Object oriented thread model,
 - Task model for legacy applications
 - Map Reduce model for data-intensive applications
 - Custom tools such as Design Explorer for parameter sweep studies
- Easy to use management tool for SLA and QoS negotiation and resource allocation.



Gridbus Broker: A Scheduler for Automatic Deployment of Applications on Global Grids

Web: <http://www.gridbus.org/broker>

The Gridbus broker is an advanced service-oriented meta-scheduler for compute and data Grids, with support for a wide range of Grid middleware and services. It takes care of many functions that Grid applications require including discovering the right resources for a particular user application, scheduling jobs in order to meet deadlines and handling faults that may occur during execution. In particular, the broker provides capabilities such as resource selection, job scheduling, job management and data access to any application that requires distributed Grid resources for execution. The broker handles communication with the resources running different Grid middleware, job failures, varying resource availability, and different user objectives such as meeting a deadline for execution or limiting execution within a certain budget. Hence, it makes Grids more appealing and approachable to user communities who want to access the increased computing power but are not familiar with using distributed systems.



The Grid Resource Broker has been used in a variety of scenarios and application domains by different scientific and business organizations. These include executing data mining programs on grid resources (European Union Data Mining Grid led by DaimlerChrysler and University of Ljubljana); integrating different kidney models and visualizing them (Melbourne Medical School and Université d'Evry, France); business applications (Infosys and HCL) and exploring semantics-based composition and trust in Grids (Anna University as part of the Indian National Grid), to name a few. The broker is hosted as an open-source project on Sourceforge.net, a website where any interested developer can join a project they are interested in, download the source code and contribute to it. This ensures that the latest source code from the Project is directly available to the public and partners/users are able to contribute towards further enhancement of our technologies.

QoS-Oriented Grid Workflow Engine

Web: <http://www.gridbus.org/workflow>

The emerging e-Research paradigm enables researchers from different disciplines and organisations to engage in collaborative scientific investigation. They need to share geographically distributed resources owned by different organisations. e-Research applications need to negotiate with resource providers for guarantees on access time, duration and level of quality of service (QoS). To meet QoS requirements of e-Research application workflows, this project aims to develop Grid technologies that support (a) QoS-based scheduling of e-Research application workflows on distributed resources, (b) mechanisms for formulating, negotiating and establishing service level agreements (SLA) with resource providers and (c) SLA-based allocation and management of resources. Specifically, the project aims to:

- Define an architectural framework and principles for the development of QoS-based workflow management and SLA-based resource allocation systems,
- Develop QoS-based algorithms for scheduling e-Research workflow applications,
- Develop SLA-based negotiation protocols and resource allocation algorithms,
- Implement a prototype system by incorporating the algorithms and policies developed above, and
- Develop real world demonstrators in various scientific domains such as life sciences.

Key Reference: [1] Jia Yu and Rajkumar Buyya, Scheduling Scientific Workflow Applications with Deadline and Budget Constraints using Genetic Algorithms, *Scientific Programming Journal*, Volume 14, Issue 3-4, ISSN: 1058-9244, IOS Press, Amsterdam, The Netherlands, Nov. 2006.

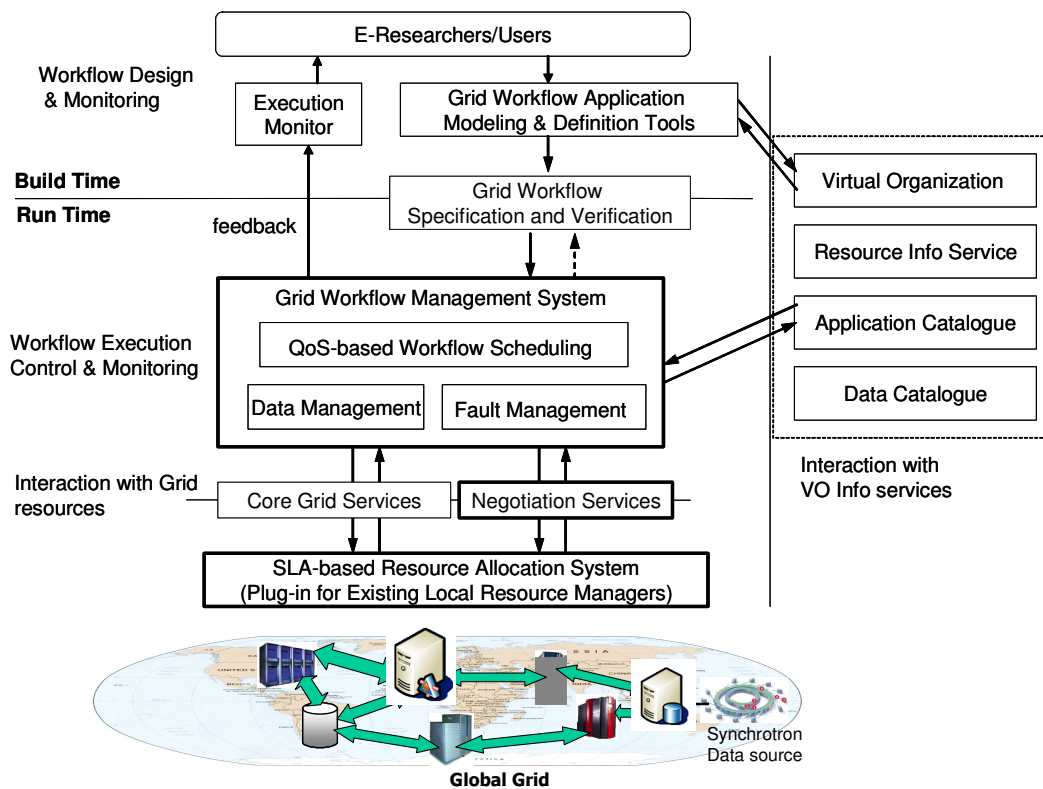


Fig. 1: Architecture of QoS-based workflow management and resource allocation system.

GridSim: A Toolkit for Modelling and Simulating Grid Computing Environments

Web: <http://www.gridbus.org/gridsim>

GridSim is a software platform that enables users to model and simulate the characteristics of Grid resources and networks with different configurations. GridSim is of great value to both students and experienced researchers who want to study Grids, or test new algorithms and strategies in a controlled environment. By using GridSim, they are able to perform repeatable experiments and studies that are not possible in a real dynamic Grid environment. Key features of GridSim are:

- Various allocation or scheduling policies can be made and integrated into GridSim easily, by extending them from one of the classes.
- Has the infrastructure or framework to support advance reservation, auction and Data Grid functionalities of a Grid system.
- Has the ability that reads workload traces taken from supercomputers for simulating a realistic Grid environment. This functionality is useful for testing a resource scheduling problem.
- Incorporates a background network traffic functionality based on a probabilistic distribution. This is useful for simulating over a public network where the network is congested.

Research students in the CLOUDS Laboratory are themselves heavy users of GridSim and extend it whenever necessary for their own research needs. In the last 5 years, GridSim has been continuously extended in this manner to include many new capabilities and has also received contributions from external collaborators. In particular, National University of Singapore has contributed a QoS-based network module, and The University of Ljubljana has contributed a DataGrid module. Academic and industrial users of GridSim include: IBM, Unisys, HP, University of Southern California, France Telecom, Indian Institute of Technology, and Sweden's Umeå University. The table below lists some of the more prominent users of GridSim.

Table 1: Various users of GridSim and their targeted application domain for simulation.

Application Domain	Organisation
Scientific Workflows	The University of Southern California, USA
Business Grids	IBM Research Lab
Grid Resource and Virtual Organisation	Umeå University, Sweden
Network modelling	National University of Singapore
Grid Security Studies	France Telecom
Scheduling Studies	University of Malay
Grid economics	Technical University of Catalunya, Spain
Grid Market Studies	Indian Institute of Technology
Semantic Grid Studies	Monash University
Utility-based Resource Management	The University of Manchester, UK
DataGrid Simulation	The University of Ljubljana, Slovenia.
Data Centre Modelling	Unisys, USA
Multi-Criteria Grid Scheduling	Poznan Supercomputing Center, Poland
Hierarchical Scheduling	Universidad Complutense de Madrid, Spain
Grid Network Buffer	The University of Castilla La Mancha, Spain

InterGrid: Peering Architecture and Policies for Internetworking Disparate Grids

Web: <http://www.gridbus.org/intergrid>

Grid computing enables the creation of Cyberinfrastructure for e-Research applications. Several nations around the world including Australia have developed their own national Grids based on the notion of virtual organisations. These dispersed Grid initiatives have resulted in islands of Grids without any support for peering arrangements between them. This limitation will impede realisation of full potential of the Grid computing paradigm. This InterGrid project aims to revolutionise Grid computing by investigating and developing (a) architectural principles for interlinking Grids, (b) mechanisms for resource provisioning and allocation within and across Grids and (c) peering policies and algorithms for inter-Grid resource management.

An Application Driver: Scientists from U.S.A, France, New Zealand and Australia have developed mathematical models of kidney functions and have been sharing these models via Grids. It is easy to extrapolate this to sharing of different models related to other organs that are developed within Grids dedicated to them. In order to build a complete model of the human physiology (e.g. IUPS Physiome Project) one needs the capability that supports composition of models from different Grids. These models may be discovered through distributed information services enabled by peering of such Grids, which are controlled by the respective communities. Realising this scenario requires participants to allocate resources from different islands of Grids in a seamless manner, and permit peering among Grids, which are under different administrative policies and political boundaries – as indicated in Figure 1.

Key Reference: Marcos Dias de Assunção, Rajkumar Buyya and Srikumar Venugopal, [InterGrid: A Case for Internetworking Islands of Grids](#), Concurrency and Computation: Practice and Experience, Online ISSN: 1532-0634; Print ISSN: 1532-0626, Wiley Press, New York, USA, 2007.

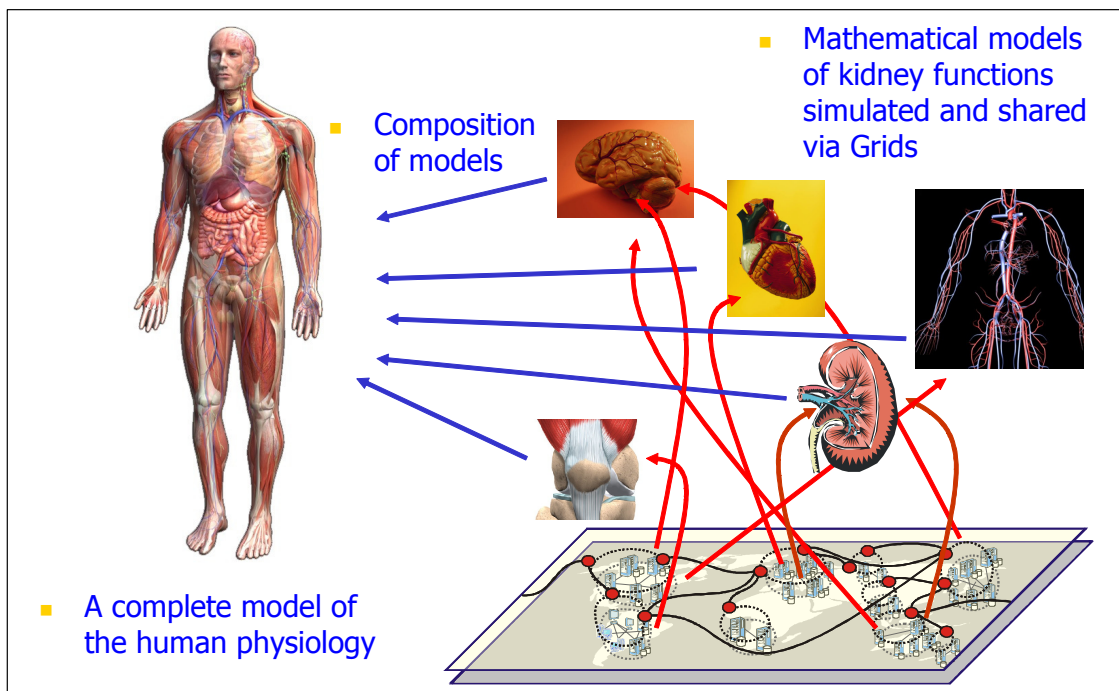


Fig. 1: InterGrid-based Integrated Human Physiome Environment.

iCDN: Internetworking of Content Delivery Networks

Web: <http://www.gridbus.org/cdn>

Content Delivery Networks (CDNs) replicate content over several mirrored Web servers, strategically placed at various locations to deal with flash crowds and to enhance response time. The requirements for providing high quality service through global coverage might be an obstacle for new providers, as well as affecting commercial viability of the existing ones. Although many CDN providers exist, they do not cooperate in delivering content to end users in a scalable manner. This project aims to provide a means for distinct CDNs to coordinate and cooperate with other CDNs, by investigating and developing (a) an architecture for an open and decentralized system to support effective internetworking between CDNs achieved through peering arrangement; (b) protocols for service delivery in a cooperative environment of CDNs; (c) economic models for an effective content replication policy; and (d) policies for autonomic management of service level through resource negotiation in an on-demand basis.

An Application Driver: An internetworking of CDNs is formed by a set of autonomous CDNs, which cooperate through a mechanism that provides facilities and infrastructure for cooperation in order to virtualize multiple providers. Architecture of a system to assist the creation of internetworking between CDNs is shown in Figure 1. Such a constellation permits flexible resource sharing and dynamic collaboration between autonomous CDNs in the form of Virtual Organizations (VOs). The 'resource sharing' approach in the internetworked CDNs model endeavours to balance a CDN's service requirements against the high costs of deploying customer-dedicated and therefore over-provisioned resources. Proper management and cooperation will enable a CDN to avoid violating SLAs even when the service demands could not have been predicted ahead of time.

Key Reference:

- [1] Buyya, R., Pathan, A. M. K., Broberg, J., and Tari, Z. A Case for Peering of Content Delivery Networks. *IEEE Distributed Systems Online*, 7(10), USA, Oct. 2006.

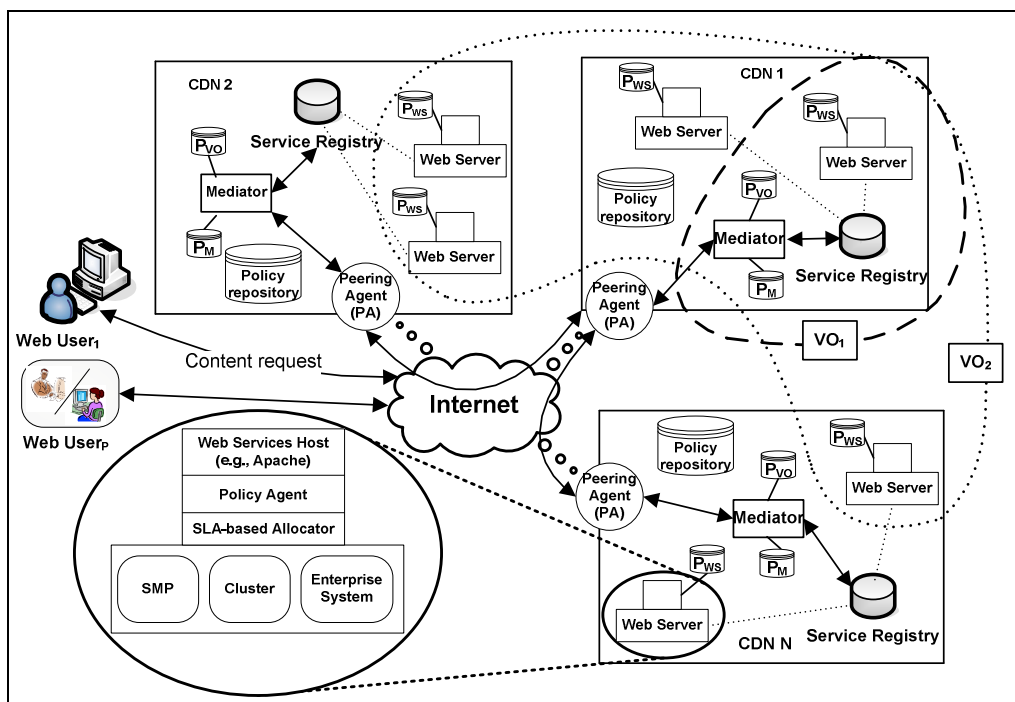


Fig. 1: Architecture of a system to assist the creation of internetworked CDNs

10. Software Releases

1. Grid Service Broker (v.3.1) Software

The Gridbus Project at the University of Melbourne (Australia) released a new version of the Grid Service Broker. The broker provides capabilities such as resource selection, job scheduling, job management and data access to any application that requires distributed grid resources for execution. The broker handles communication with the resources running different grid middleware, job failures, varying resource availability and different user objectives, such as meeting a deadline for execution or limiting execution within a certain budget.

With the current release, version 3.1, a new organizational structure is provided for the broker, wherein the core is separated from additional capabilities provided as plug-ins that can be selected according to usage requirements. A new Ant build file has been provided to enable selection of plug-ins and the automatic configuration of the broker thereof. Also available is a new external plug-in that uses the capabilities of the Gridbus broker to schedule grid workflows.

New features include:

- Plug-in structure for middleware and programming models.
- Ant build file for automatic downloading and configuration of broker installation.
- Workflow engine plug-in.
- Thread programming model plug-in (similar to Alchemi Grid Threads).

Gridbus in e-Science Enablements

The Gridbus Broker has been used in Grid enabling several e-Science and e-Business applications. The most recent usages include:

- European Union-funded Data Mining Grid Project, which developed set of grid-based data-mining tools and used Gridbus Broker in managing execution of data mining computations on global grids: www.datamininggrid.org/.
- KidneyGrid partners, including Melbourne Medical School and Université d'Evry (France), created a grid portal that integrated distributed kidney models.
- As part of the Australian National Grid (APACGrid), a portal for docking of molecules from CDB with protein target with the aim of discovery potential drug candidates: <http://grid.apac.edu.au/OurUsers/MolecularDocking>.

Base Technologies

The Gridbus Broker v3.1 supports/uses the following middleware: Globus 2.4.x, Globus 4.0.2, Alchemi 1.0.6, Condor 6.8.4, OpenPBS 2.3, SGE, NWS 2.8, SRB(Storage Resource Broker) 3.x
The Gridbus Broker v3.1 supports/uses the following programming model:

- Task/Job model.
- Gridbus Workflow.
- Grid Threading Programming Model.

The Gridbus Broker v3.1 can utilize a resource via SSH for submitting and executing grid jobs on: OpenPBS 2.3, Condor 6.8.4, SGE, Fork (on Unix-like OSes). The broker source code, binaries, documentation and manual can be downloaded from www.gridbus.org/broker/.

2. GridSim Toolkit 5.0

The Cloud Computing and Distributed Systems (CLOUDS) Laboratory at the University of Melbourne, Australia has released the next-version of Grid simulation software, the GridSim Toolkit 5.0.

This new version of GridSim brings a new package (i.e. gridsim.parallel) that provides:

- A graphical user interface for debugging resource allocation policies.
- Several allocation policies for scheduling parallel jobs on clusters and supercomputers. The policies include aggressive backfilling, conservative backfilling, advance reservation with conservative backfilling, selective backfilling and aggressive backfilling with multiple resource partitions.
- An implementation of the workload model by Lublin and Feitelson for modelling the workload of clusters and supercomputers.
- A data structure to facilitate the scheduling of jobs and advance reservations. This data structure is described as an appendix on Marcos Assuncao's PhD thesis.
- Logging features using Java logging API.

In addition, other improvements have made GridSim more compatible with Java 5 and 6. Some bugs have been fixed and some changes in SimJava were required to enable a simulation to be paused and resumed.

All components developed as part of the GridSim Toolkit are released as "open source" under the GPL license to encourage innovation and pass full freedom to our users.

The early version of our GridSim toolkit has been used/downloaded by several academic and commercial organizations around the world including: University of Southern California (USA), California Institute of Technology (USA), Argonne National Labs (USA), University of Manchester (UK), CERN, Universidad de Santiago de Compostela (Spain), Indian Institute of Technology, Tsinghua University (China), Sun Microsystems, IBM Research, Unisys, HP, Northrop Grumman Information Technology, British Telecom and EMC Corp.

The contributors to the GridSim software (from early to new versions) are:

- * Rajkumar Buyya, CLOUDS Lab @ The University of Melbourne.
- * Manzur Murshed, GSCIT @ Monash University, Australia.
- * Anthony Sulistio, CLOUDS Lab @ The University of Melbourne.
- * Gokul Poduval and Chen-Khong Tham, Dept. of Electrical & Computer Engineering @ National University of Singapore.
- * Marcos Dias de Assuncao, INRIA Lyon @ Ecole Normale Supérieure de Lyon
- * Uros Cibej and Borut Robic, Faculty of Computer and Information Service, The University of Ljubljana, Slovenia.
- * Agustin Caminero, Department of Computing Systems, Universidad de Castilla La Mancha (UCLM), Spain.
- * James Broberg, CLOUDS Lab @ The University of Melbourne.
- * Saurabh Garg, CLOUDS Lab @ The University of Melbourne.

CloudSim 1.0 released

Melbourne 07 April 2009 *The Melbourne CLOUDS Lab has just released a Cloud Simulation software, called CloudSim.*

CloudSim supports research and development in the emerging field of Cloud Computing, and offers the following novel features: (i) support for modelling and simulation of large scale Cloud computing infrastructure, including data centres on a single physical computing node; and (ii) a self-contained platform for modelling data centres, service brokers, scheduling, and allocations policies.

Among the unique features of CloudSim, there are: (i) availability of virtualization engine, which aids in creation and management of multiple, independent, and co-hosted virtualized services on a data centre node; and (ii) flexibility to switch between space-shared and time-shared allocation of processing cores to virtualized services. These compelling features of CloudSim would speed up the development of new algorithms, methods, and protocols in Cloud computing, hence contributing towards quicker evolution of the paradigm.

All components developed as part of the CloudSim Toolkit are released as "open source" under the GPL license to encourage innovation and pass full freedom to the users.

As a simulation tool for an emerging technology, there are several issues related to Cloud Computing that still in development. The CloudSim team has done its best to address as many issues as possible, considering not only research developed in the CLOUDS Lab but also recent Cloud-related research that has been published in academic journals and conferences. Nevertheless, there may be features that are required by Cloud researches and that are not present in this version of CloudSim.

On the other hand, there may be features that are not required by Cloud researchers. Hence, the CloudSim team will be happy to receive feedback on usefulness of the current features, and also to receive suggestions on which features should be present in the final version of the tool. Also, any feedback will be welcomed.

The software can be downloaded from <http://www.gridbus.org/cloudsim/>

Aneka: A Software Technology to Simplify .NET-based Enterprise Clouds

Aneka 1.0 – Release Notes – March 27, 2009.

Manjrasoft Pty Ltd, Australia

What's in Aneka 1.0 ?

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The Aneka 1.0 distribution comes with the following features:

The basic infrastructure of the system comprising client and server components for setting up an Enterprise Cloud/Grid system with scheduling and execution nodes.

- A configurable container hosting the core of Aneka that can be started as Window Service or as a console application.

- A set of ready to use programming models for developing Enterprise Cloud/Grid applications with Aneka:

[1] Thread Programming Model: this model is the best solution to adopt for leveraging the computation of a multi-threaded application on a distributed system.

[2] Task Programming Model: this model allows quickly prototyping and implementing independent bag of tasks applications.

[3] MapReduce Programming Model: this model is an implementation of the popular MapReduce programming model proposed by Google for Aneka systems.

- A collection of sample applications that give the feeling of what can be done by using the supported programming models.

- A software development kit containing step by step guides for developing applications with the Thread, Task, and MapReduce Programming Models.

- A Design Explorer allowing user to quickly prototype Parameter Sweeping application for Aneka.

- A comprehensive API documentation covering the supported programming models and the Aneka client APIs.

- A Windows integrated security mechanism to authenticate and authorise user's access to Aneka

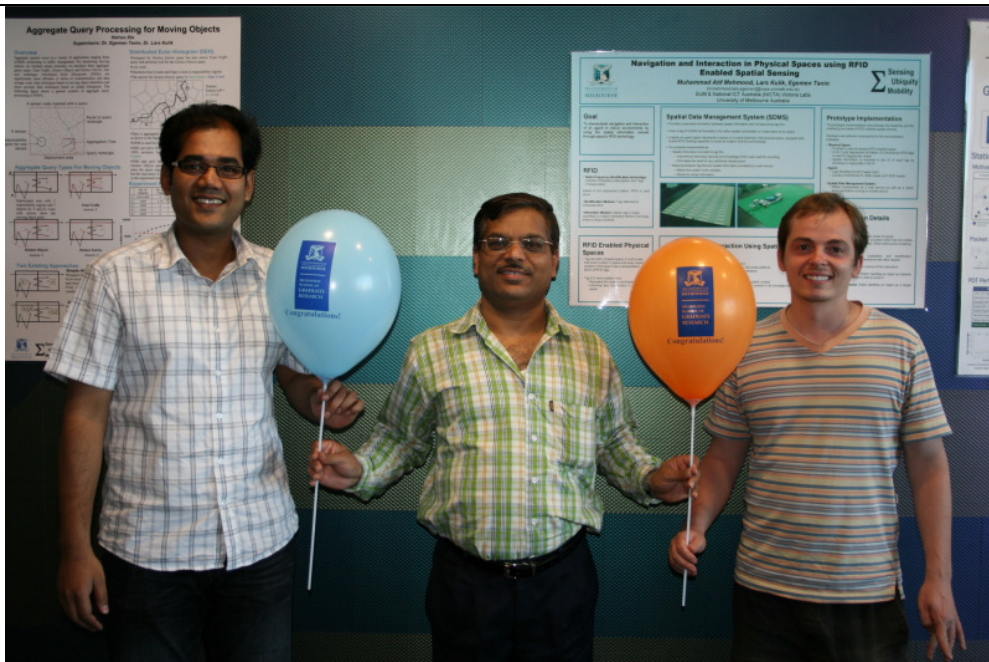
- A RDBMS persistence supports both SQL Server Express 2005 version 9 and MySQL 5.1.30.

Additional and updated content concerning samples and documentation can be downloaded from the Manjrasoft Website: <http://www.manjrasoft.com/download.html>

11. Moments with Visitors, Colleagues and International Hosts



Raj receiving “2009 IEEE Medal for Excellence in Scalable Computing” at CCGrid 2009 from Dr. Manish Parashar, Chair of the Medal Committee.



Pathan and Marco's successful submission of their PhDs on the same day!



Java book release by Helen Hayes (Director of Melbourne Knowledge Transfer) and Chris Fleischmann (Sun); Raj and Chu as co-authors.



Receiving Best Paper Award from ACSC 2009 Conference, New Zealand. Raj, ACSC 2009 PC Chair (Dr. Bernard Mans), and Saurabh Garg.