

Cloud Computing and Distributed Systems Laboratory and the Cloudbus Project



Annual Report - 2010



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 2010, which has been an extraordinary year in terms of research quality and international recognition of its members. 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 2010 are:



- The Lab successfully completed two large research projects: (i) ARC (Australian Research Council) Discovery Project “InterGrid: Peering Architecture and Policies for Internetworking Disparate Grids” and (ii) post-funding activities of 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 assisted its spin-off company, Manjrasoft, which has released Aneka 2.0 software and filed its PCT patent application to national phase in USA & India.
- One of our Lab members (Dr. Broberg) has ventured into commercialisation of Content Delivery Networks over Clouds (MetaCDN) R&D carried out during his stay with us.
- Members of CLOUDS Lab have authored 30 publications, which include 8 journal papers, and 15 conference papers.
- The Lab's flagship Cloudbus Project has released “open source” CloudSim 2.0 Toolkit, which is used by several researchers in academia and industries around the world.
- Members have presented over 37 invited talks that include 7 keynotes delivered at international conferences held in USA, Australia, India, Vietnam, China, and Korea.
- The Lab successfully hosted research activities of over 20 scholars: 9 PhD students, 7 Research Fellows (5 at PostDoc level and 2 Software Engineers), and couple of Masters/honours students. Three Ph.D students have graduated.
- Lab members have been recognised for their outstanding contribution to the field of distributed computing by awards such as “Scopus Young Researcher of the Year 2010 Award: Finalist”, “Google Australia Eureka Prize for Innovation in Computer Science: 2010 Finalist”, and “2010 Asia Pacific Frost & Sullivan New Product Innovation Award”.
- Received “Best Paper Award” from the 24th IEEE International Conference on Advanced Information Networking and Applications (AINA 2010), Perth, Australia, April 20-23, 2010.
- The Lab housed several (short and long term) international visitors (academic and PhD students) from USA, Canada, and India.
- Members of the Lab have led community efforts by (a) involving in the organisation of conferences (e.g., CCGrid 2010 in Melbourne), (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: www.cloudbus.org

2. The Team

Director:

- Professor Rajkumar Buyya

Research Staff:

- Dr. James Broberg
- Mr. Xingchen Chu
- Dr. Christian Vecchiola
- Dr. Javadi Bahman
- Dr. Rodrigo N. Calheiros
- Mr. Dileban Karunamoorthy
- Dr. Mukaddim Pathan
- Dr. Adam Barker
- Dr. Saurabh Garg

PhD Students

- Mr. Mustafizur Rahman
- Mr. Suraj Pandey
- Mr. Michael Mattess
- Mr. William Voorsluys
- Mr. Mohsen Amini
- Mr. Anton Beloglazov
- Mr. Amir Vahid
- Ms. Linlin Wu
- Mr. Adel Toosi

Masters by Research Students

Collaborators

- Colleagues holding research grants with the Director
- International Visitors
- Many collaborators involved in extending and using the Cloudbus software.

3. Competitive Grants Funded Projects and Programs

Australian Research Council (ARC)

- 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).
- R. Buyya, Megha: Utility Oriented Federation of Cloud Computing Environments for Scaling of Application Services, Discovery Project, ARC, 2010-2012. Amount: \$280,000.

Industry and Melbourne University Grants

- R. Buyya and S. Pandey, "Access to Amazon EC2 and S3 Public Cloud", Academic Research Grant—Equipment Access, Amazon Inc., Seattle, USA, 2010. Amount Equivalent: US\$6,000.
 - R. Buyya, "Desktop Virtualisation and Cloud Computing", Academic Research Grant—Equipments, IBM, Melbourne, Australia, 2010-2011. Amount Equivalent: A\$12,000.
 - A. Melatos, G. Taylor, R. Buyya, R. Kotagiri, P. Farrell, W. Moran, P. Hall, and A. Delaigle, "Designing the LIGO Australia Data Centre", SRE Implementation Fund, The University of Melbourne, 2011. Amount: \$95,000.
 - R. Buyya and Aneka Team, "Scaling e-Science Applications using Azure Public Cloud", Academic Research Grant—Equipment Access, Microsoft, Seattle, USA, 2010-2013. Amount Equivalent: Approx. US\$180,000.
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4. Publications

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

Year Publication Type	2002	2003	2004	2005	2006	2007	2008	2009	2010
Books/Proceedings Edited	1	1	1	1	5	4	3	5	2
Journal Papers	6	1	4	5	6	4	10	13	8
Book Chapters	1	0	0	4	4	2	4	11	3
Conference Papers	4	7	9	16	15	24	22	27	15
Magazine/Other Articles	0	0	1	2	4	2	0	1	2
Total	12	9	15	28	34	36	39	57	30

Book Chapters

- Marco Netto and Rajkumar Buyya, [Resource Co-allocation in Grid Computing Environments](#), Handbook of Research on P2P and Grid Systems for Service-Oriented Computing: Models, Methodologies and Applications, 476-494pp, N. Antonopoulos, G. Exarchakosa, M. Li and A. Liottac (eds), ISBN-13: 978-1615206865, IGI Global, USA, Feb. 2010.
- Tomasz Kobialka, Rajkumar Buyya, Peng Deng, Lars Kulik, Marimuthu Palaniswami, [Sensor Web: Integration of Sensor Networks with Web and Cyber Infrastructure](#), Handbook of Research on Developments and Trends in Wireless Sensor Networks: From Principle to Practice, H. Jin and W. Jiang (eds), ISBN: 978-161-520-701-5, IGI Global, USA, Feb. 2010.
- Chao Jin and Rajkumar Buyya, Dataflow Computations on Enterprise Grids, [Selected Topics in Communication Networks and Distributed Systems](#), S. Misra, S. C. Misra, I. Woungang (eds), ISBN: 978-981-283-943-5, World Scientific Publishing Co., Singapore, May 2010.

Proceedings Edited

- Manish Parashar and Rajkumar Buyya, *Proceedings of the 10th IEEE/ACM International Symposium on Cluster, Cloud, and Grid Computing (CCGrid 2010, May 17-20, 2010, Melbourne, Australia)*, ISBN 978-0-7695-4039-9, IEEE CS Press, Los Alamitos, CA, USA.
- Pranay Chaudhuri, Sukumar Ghosh, Rajkumar Buyya, Jian-Nong Cao, and Deepak Dahiya, *Proceedings of the First International Conference on Parallel, Distributed and Grid Computing (PDGC 2010, October 28-30, 2010, Wagnaghat, Solan, India)*, ISBN 978-1-4244-7672-5, IEEE Press, Piscataway, NJ, USA.

Journal Papers

- Rodrigo N. Calheiros, Rajkumar Buyya, and Cesar A. F. De Rose, [Building an automated and self-configurable emulation testbed for grid applications](#), Software: Practice and Experience (SPE), Volume 40, Number 5, Pages: 405-429, ISSN: 0038-0644, Wiley Press, New York, USA, April 25, 2010.
- Mustafizur Rahman, Rajiv Ranjan, and Rajkumar Buyya, [Cooperative and Decentralized Workflow Scheduling in Global Grids](#), Future Generation Computer Systems, Volume 26, Number 5, Pages: 753-768, ISSN: 0167-739X, Elsevier Science, Amsterdam, The Netherlands, May 2010.
- SungJin Choi and Rajkumar Buyya, [Group-based Adaptive Result Certification](#)

- [Mechanism in Desktop Grids](#), Future Generation Computer Systems, Volume 26, Number 5, Pages: 776-786, ISSN: 0167-739X, Elsevier Science, Amsterdam, The Netherlands, May 2010.
9. Marcos Dias de Assuncao, Alexandre di Costanzo and Rajkumar Buyya, [A Cost-Benefit Analysis of Using Cloud Computing to Extend the Capacity of Clusters](#), Journal of Cluster Computing, Volume 13, Number 3, Pages: 335-347, ISSN: 1386-7857, Springer, Netherlands, September 2010.
 10. Saurabh Kumar Garg, Rajkumar Buyya, and Howard Jay Siegel, [Time and Cost Trade-off Management for Scheduling Parallel Applications on Utility Grids](#), Future Generation Computer Systems, Volume 26, Number 8, Pages: 1344-1355, ISSN: 0167-739X, Elsevier Science, Amsterdam, The Netherlands, October 2010.
 11. Chee Shin Yeo, Srikumar Venugopal, Xingchen Chu, Rajkumar Buyya, [Autonomic Metered Pricing for a Utility Computing Service](#), Future Generation Computer Systems, Volume 26, Number 8, Pages: 1368-1380, ISSN: 0167-739X, Elsevier Science, Amsterdam, The Netherlands, October 2010.
 12. Kyong Hoon Kim, Wan Yeon Lee, Jong Kim, and Rajkumar Buyya, SLA-Based Scheduling of Bag-of-Tasks Applications on Power-Aware Cluster Systems, IEICE Transactions on Information and Systems, Volume E93-D, Number 12, Pages: 3194-3201, ISSN: 0916-8532, Institute of Electronics, Information and Communication Engineers (IEICE) Press, Tokyo, Japan, Dec. 2010.
 13. Mustafizur Rahmana, Rajiv Ranjan, Rajkumar Buyya, [Reputation-based Dependable Scheduling of Workflow Applications in Peer-to-Peer Grids](#), Computer Networks, Volume 54, Number 18, Pages: 3341-3359, ISSN: 1389-1286, Elsevier Press, Amsterdam, The Netherlands, Dec. 20, 2010.

Magazine Papers

14. Christian Vecchiola, Dexter Duncan, and Rajkumar Buyya, [The Structure of the New IT Frontier: Market Oriented Computing](#), Strategic Facilities Magazine, Issue 10, Pages: 59-66, Pacific & Strategic Holdings Pte Ltd, Singapore, 2010.
15. Karthik Sukumar, Christian Vecchiola, and Rajkumar Buyya, [The Structure of the New IT Frontier: Aneka Platform for Elastic Cloud Computing Applications](#), Strategic Facilities Magazine, Issue 11, Pacific & Strategic Holdings Pte Ltd, Singapore, 2010.

Conference Papers

16. Suraj Pandey, Linlin Wu, Siddeswara Guru, and Rajkumar Buyya, [A Particle Swarm Optimization \(PSO\)-based Heuristic for Scheduling Workflow Applications in Cloud Computing Environments](#), Proceedings of the 24th IEEE International Conference on Advanced Information Networking and Applications (AINA 2010), Perth, Australia, April 20-23, 2010. - **Best Paper Award**.
17. Bhathiya Wickremasinghe, Rodrigo N. Calheiros, and Rajkumar Buyya, [CloudAnalyst: A CloudSim-based Visual Modeller for Analysing Cloud Computing Environments and Applications](#), Proceedings of the 24th IEEE International Conference on Advanced Information Networking and Applications (AINA 2010), Perth, Australia, April 20-23, 2010.
18. Suraj Pandey, Kapil Kumar Gupta, Adam Barker and Rajkumar Buyya, [Minimizing Execution Cost when using Globally Distributed Cloud Services](#), Proceedings of the 24th IEEE International Conference on Advanced Information Networking and Applications (AINA 2010), Perth, Australia, April 20-23, 2010.
19. Amir Vahid Dastjerdi, Sayed Tabatabaei, and Rajkumar Buyya, [An Effective Architecture for Automated Appliance Management System Applying Ontology-Based Cloud Discovery](#), Proceedings of the 10th IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGrid 2010), Melbourne, Australia, May 17-20, 2010.
20. Anton Beloglazov and Rajkumar Buyya, [Energy Efficient Resource Management in Virtualized Cloud Data Centers](#), Doctoral Symposium, Proceedings of the 10th IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGrid 2010),

- Melbourne, Australia, May 17-20, 2010.
21. Anton Beloglazov and Rajkumar Buyya, [Energy Efficient Allocation of Virtual Machines in Cloud Data Centers](#), Proceedings of the 10th IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGrid 2010), Melbourne, Australia, May 17-20, 2010.
 22. Rajkumar Buyya, Rajiv Ranjan, and Rodrigo N. Calheiros, [InterCloud: Utility-Oriented Federation of Cloud Computing Environments for Scaling of Application Services](#), Proceedings of the 10th International Conference on Algorithms and Architectures for Parallel Processing (ICA3PP 2010, LNCS 6081, Springer, Germany), 13-31pp, Busan, South Korea, May 21-23, 2010. - **Keynote Paper.**
 23. Nithiapidary Muthuvelu, Ian Chai, Eswaran Chikkannan, and Rajkumar Buyya, [On-line Task Granularity Adaptation for Dynamic Grid Applications](#), Proceedings of the 10th International Conference on Algorithms and Architectures for Parallel Processing (ICA3PP 2010, LNCS 6081, Springer, Germany), 266-277pp, Busan, South Korea, May 21-23, 2010.
 24. Mohsen Amini Salehi and Rajkumar Buyya, [Adapting Market-Oriented Scheduling Policies for Cloud Computing](#), Proceedings of the 10th International Conference on Algorithms and Architectures for Parallel Processing (ICA3PP 2010, LNCS 6081, Springer, Germany), 351-362pp, Busan, South Korea, May 21-23, 2010.
 25. Mustafizur Rahman, Md. Rafiul Hassan, Rajkumar Buyya, [Jaccard Index based Availability Prediction in Enterprise Grids](#), Proceedings of the 10th International Conference on Computational Science (ICCS 2010, Elsevier - Procedia Computer Science), Amsterdam, The Netherlands, May 31 - June 2, 2010.
 26. Rajkumar Buyya, Anton Beloglazov, and Jemal Abawajy, [Energy-Efficient Management of Data Center Resources for Cloud Computing: A Vision, Architectural Elements, and Open Challenges](#), Proceedings of the 2010 International Conference on Parallel and Distributed Processing Techniques and Applications (PDPTA 2010), Las Vegas, USA, July 12-15, 2010. - **Keynote Paper.**
 27. Michael Mattess, Christian Vecchiola, and Rajkumar Buyya, [Managing Peak Loads by Leasing Cloud Infrastructure Services from a Spot Market](#), Proceedings of the 12th IEEE International Conference on High Performance Computing and Communications (IEEE HPCC 2010), Melbourne, Australia, September 1-3, 2010.
 28. Anton Beloglazov and Rajkumar Buyya, [Adaptive Threshold-Based Approach for Energy-Efficient Consolidation of Virtual Machines in Cloud Data Centers](#), Proceedings of the 8th International Workshop on Middleware for Grids, Clouds and e-Science (MGC 2010, ACM Press, New York, USA), In conjunction with ACM/IFIP/USENIX 11th International Middleware Conference 2010, Bangalore, India, November 29 - December 3, 2010.
 29. Mustafizur Rahman, Rajiv Ranjan, and Rajkumar Buyya, [A Taxonomy of Autonomic Application Management in Grids](#), Proceedings of the The 16th International Conference on Parallel and Distributed Systems (ICPADS 2010, IEEE CS Press, USA), Shanghai, China, December 8-10, 2010.
 30. Christian Vecchiola, Mani Abedini, Michael Kirley, Xingchen Chu, and Rajkumar Buyya, [Gene Expression Classification with a Novel Coevolutionary based Learning Classifier System on Public Clouds](#), Proceedings of the 2010 Sixth IEEE International Conference on e-Science Workshops (IEEE CS Press, USA), 92-97pp, Brisbane, Australia, Dec. 7, 2010.

5. Invited Presentations and Outreach

By the Lab Director:

Keynote Talks at International Conferences

1. Cloud Computing: The Next Revolution in Information Technology, International Conference on Advanced Computing and Applications (ACOMP 2010), Ho Chi Minh City, Vietnam, March 3-5, 2010.
2. Cloud Computing: The Next Revolution in Information Technology, 10th International Conference on Algorithms and Architectures for Parallel Processing (ICA3PP 2010), Busan, South Korea, May 21-23, 2010.
3. Cloud Computing: The Next Revolution in Information Technology, 2010 World Congress in Computer Science, Computer Engineering, and Applied Computing (WorldComp 2010), Las Vegas, USA, June 12-15, 2010.
4. Panel - Services, Security, and Privacy in Cloud Computing, 12th IEEE International Conference on High Performance and Communications (HPCC 2010), Sept. 1-3, 2010, Melbourne, Australia.
5. Market-Oriented Cloud Computing and the Aneka Platform, International Workshop on Internet and Distributed Computing Systems (IDCS 2009), In conjunction with 12th IEEE International Conference on High Performance and Communications (HPCC 2010), Sept. 1-3, 2010, Melbourne, Australia.
6. Cloud Computing: The Next Revolution in Information Technology, First International Conference on Parallel, Distributed and Grid Computing (PDGC 2010), October 28-30, 2010, Wanknaghat, Solan, India.
7. Cloud Computing: Vision, Challenges, and Opportunities, 2nd International Conference on Advanced Computing (ICoAC 2010), Dec. 14-16, 2010, Chennai, India.

National Conferences

1. Cloud Computing: Vision, Hype, and Reality, Cloud Computing Twenty Ten, Sydney, Australia, March 24-25, 2010.
2. Aneka Cloud Application Platform, International Workshop on Cloud Computing, Anna University, Chennai, India, Oct. 20, 2010.
3. Cloud Computing: The Next Revolution in Information Technology, 24th CSI Karnataka Student Convention, Mysore, India, Oct. 23-24, 2010.
4. Cloud Computing with Aneka Application Platform, National Workshop on Business Excellence Through Cloud Computing, IIT Madras, Chennai, India, Dec. 15, 2010.
5. Cloud Computing: The Next Revolution in Information Technology, National Workshop on Information Technology and Cloud Computing, Karnataka Arts, Science and Commerce College, Bidar, India, Dec. 24, 2010.

Seminars - in Cloud Computing area:

1. Infosys, Hyderabad, India, Jan. 4, 2010.
2. Hyderabad University, Hyderabad, India, Jan. 4, 2010.
3. Advanced Data Processing Research Institute (ADRIN), Secunderabad, India, Jan. 5, 2010.
4. Tata Consultancy Services (TCS), Hyderabad, India, Jan. 5, 2010.
5. CMC Limited, Hyderabad, India, Jan. 5, 2010.
6. A*STAR Institute of High Performance Computing, Singapore, March 8, 2010.
7. Korea Institute of Science and Technology Information (KISTI), Daejeon, Korea, May 25, 2010.
8. Seoul National University (SNU), Seoul, Korea, May 26, 2010.
9. Kookmin University, Seoul, Korea, May 27, 2010.
10. Korea University, Seoul, Korea, May 27, 2010.

11. Inha University, Seoul, Korea, May 28, 2010.
12. Deakin University, Geelong, Australia, June 11, 2010.
13. California Institute of Technology (CalTech), Pasadena, Los Angeles, USA, July 19, 2010.
14. CSIRO, Canberra, Australia, Aug. 13, 2010.
15. The University of New South Wales, Sydney, Australia, Aug. 16, 2010.
16. Swinburne University of Technology, Melbourne, Australia, Aug. 27, 2010.
17. C-DAC Chennai, India, Oct. 19, 2010.
18. C-DAC Bangaluru, India, Oct. 21, 2010.
19. CSI (Computer Society of India), Bangaluru, India, Oct. 24, 2010.
20. Pondicherry University, Puducherry, India, Dec. 18, 2010.
21. G.Pulla Reddy Engineering College, Kurnool, India, Dec. 22, 2010.
22. Hyderabad University, Hyderabad, India, Dec. 29, 2010.

Conference Tutorials

1. Market-Oriented Cloud Computing, 10th IEEE/ACM International Symposium on Cluster, Cloud, and Grid Computing (CCGrid 2010), May 17-20, 2010, Melbourne, Australia.
2. Cloud Computing, 2nd International Conference on Advanced Computing (ICoAC 2010), Dec. 14-16, 2010, Chennai, India.

By Other Members:

Conference Tutorials

1. Christian Vecchiola (with Raj Buyya), Market-Oriented Cloud Computing, 10th IEEE/ACM International Symposium on Cluster, Cloud, and Grid Computing (CCGrid 2010), May 17-20, 2010, Melbourne, Australia.

Research Presentations

1. Suraj Pandey, Scalable Personal Health Monitoring based on Mobile and Cloud Computing, The Third IEEE International Scalable Computing Challenge (SCALE 2010), 10th IEEE/ACM International Symposium on Cluster, Cloud, and Grid Computing (CCGrid 2010), May 17-20, 2010, Melbourne, Australia.

Seminars

1. R. Mustafizur, Taxonomy of Autonomic Workflow Management in Grids, A*STAR Institute of High Performance Computing, Singapore, Sept. 27, 2010.
2. R. Mustafizur, Autonomic Workflow Management in Grids, International Islamic University, Kuala Lumpur, Malaysia, Nov. 7, 2010.

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. Editorial Board Member, *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, *Multiagent and Grid Systems: An International Journal*, ISSN: 1574-1702, IOS Press, Amsterdam, The Netherlands, 2005 onwards.
4. 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, CCGrid 2009, Shanghai, China, and CCGrid 2010, Melbourne, Australia.
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. General Chair, 10th IEEE/ACM International Symposium on Cluster, Cloud, and Grid Computing (CCGrid 2010), May 17-20, 2010, Melbourne, Australia.
2. General Chair, First International Conference on Utility and Cloud Computing (UCC 2010), December 14-16, 2010, Chennai, India.

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 IEEE International Conference on High Performance Computing (HiPC 2010), Dec. 19-22, 2010, Goa, India.
2. 11th ACM/IFIP/USENIX International Conference on Middleware, Nov. 29-Dec. 3, 2010, Bangalore, India.

3. 10th International Conference on Computational Science (ICCS 2010), May 31-June 2, 2010, Amsterdam, The Netherlands.
4. 10th International Conference on Algorithms and Architectures for Parallel Processing (ICA3PP 2010), May 21-23, 2010, Busan, Korea,
5. 24th IEEE International Conference on Advanced Information Networking and Applications ([AINA 2010](#)), April 20-23, 2010, Perth, Australia.
6. 19th International Heterogeneity in Computing Workshop ([HCW 2010](#)), April 19, 2010, Atlanta, USA.
7. 25th ACM Symposium on Applied Computing (ACM SAC 2010), March 22-26, 2010, Sierre, Switzerland.
8. 33rd Australasian Computer Science Conference (ACSC 2010), Jan. 18-22, 2010, Brisbane, Australia.
9. 11th International Conference on Distributed Computing and Networking (ICDCN 2010), Jan. 3-6, 2010, Kolkata, India.

Community Information Sources

- Maintained a Grid Computing Information Centre at: <http://www.gridcomputing.com>, whose newsletter mailing list has over 2500 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>
- Co-Moderator for Computing Research Repository (CoRR, <http://arxiv.org/corr/>)'s subject on "Distributed, Parallel, and Cluster Computing".

By Other Members:

Chairs and Memberships

1. Suraj Pandey, Local Organizing Co-chair, 10th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid 2010) May 17-20, 2010, Melbourne, Australia.
2. Anton Beloglazov, Local Organizing Committee Member, 10th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid 2010) May 17-20, 2010, Melbourne, Australia.
3. Christian Vecchiola, Editorial Board Member, Advancements in Distributed Computing and Internet Technologies: Trends and Issues, IGI Global.
4. R. Mustafizur, 3rd IEEE International Workshop on Internet and Distributed Computing Systems (IDCS'10), Melbourne, Sept. 2, 2010.

Technical Program Committee Memberships

1. Suraj Pandey, CISIS 2010 - International Conference on Complex, Intelligent and Software Intensive Systems. Track: "Scientific Computing: Infrastructures and Applications". February 15th - 18th 2010, Krakow, Poland.
2. Christian Vecchiola, 2010, 3rd IEEE International Workshop on Internet and Distributed Computing Systems (IDCS'10), September 1-3, 2010, Melbourne, Australia.
3. Rodrigo N. Calheiros, First International Conference on Utility and Cloud Computing (UCC 2010), December 14-16, 2010, Chennai, India.

Conference Tutorials

1. Christian Vecchiola (with Raj Buyya), Market-Oriented Cloud Computing, 10th IEEE/ACM International Symposium on Cluster, Cloud, and Grid Computing (CCGrid 2010), May 17-20, 2010, Melbourne, Australia.

7. International Visitors

1. Prof. T. Selvi, Anna University, Chennai, India, May 2010.
2. Dr. Srinivasa K G, MSRIT, Bangalore, India, Aug 2010-Jan 2011 - on BOYSCAST Fellowship of Govt. of India.
3. Dr. R. Thulasiram, University of Manitoba, Sept. 2010.
4. Prof. G. Fox, Indiana University, USA, Sept. 2, 2010.

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 taught *Distributed Systems* subject and co-lectured *Cluster and Grid Computing* subject.



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. We supported 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. This prototype leverages Aneka. In 2010, I focused in improving the features of Offspring and, together with Mr. Abedini, integrated new algorithms for Co-evolutionary classification.

Cloud Computing is an interesting new opportunity for companies to leverage on demand third parties for IT infrastructure, services, and applications. It allows dynamically provisioning virtual hardware, scale applications according to their needs and integrating 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. In particular, in 2010 we have focused in improving the dynamic provisioning infrastructure within Aneka and devising more intelligent policies for dynamic resource provisioning. Together with Prof. Buyya, I am also writing a book on High Performance Cloud Computing.

In 2011, 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 improving the support for MapReduce and completing the book co-authored with Prof. Buyya.

C. Vecchiola, D. Duncan, and R. Buyya, *The Structure of the New IT Frontier: Market Oriented Computing*, Strategic Facilities Magazine, Issue 10, Pages: 59-66, Pacific & Strategic Holdings Pte Ltd, Singapore, 2010.

M. Mattess, C. Vecchiola, and R. Buyya, *Managing Peak Loads by Leasing Cloud Infrastructure Services from a Spot Market*, Proceedings of the 12th IEEE International Conference on High Performance Computing and Communications, Melbourne, Australia, September 1-3, 2010.

C. Vecchiola, M. Abedini, M. Kirley, X. Chu, and R. Buyya, *Gene Expression Classification with a Novel Coevolutionary based Learning Classifier System on Public Clouds*, Proceedings of the 2010 Sixth IEEE International Conference on e-Science Workshops (IEEE CS Press, USA), 92-97pp, Brisbane, Australia, Dec. 7, 2010.

Member Self Profile: James Broberg

In 2010 I was employed as an Australian Postdoctoral Fellow (APD, Content Delivery Networks). 2010 was the final year of my fellowship, and my 4th year in the department. My primary responsibility was performing research activities around a Discovery Grant, "Coordinated and Cooperative Load Sharing between Content Delivery Networks" (DP0881742, 2008-2010).

I have been developing a framework called MetaCDN [1] that enables coordinated and cooperative load sharing amongst different Content Delivery Network (CDN) and Cloud Storage providers, with emphasis on measuring and disseminating load information, performing

request assignment / redirection, and enabling content replication amongst participating CDNs on a wide-area "Internet" scale. I have addressed these core issues from theoretical, simulation and software engineering perspectives to test the performance and computational demands of competing and newly developed algorithms, and have published research papers and created software documenting these findings.

In 2010 I placed a larger focus on engineering aspects of MetaCDN, developing a proof of concept implementation to bring the MetaCDN platform to a commercial grade. A provisional patent application was also filed around key novel aspects of the MetaCDN technology.

Other key activities in 2010 were teaching a masters-level subject, "Internet Technologies", in Semester 1, and co-editing a book called "Cloud Computing: Principles and Paradigms" [2] (to appear, 2011) with Prof. Rajkumar Buyya and Prof. Andrzej Goscinski. I also contributed to two chapters to this book.

[1] MetaCDN – <http://www.metacd.com>

[2] Cloud Computing Principles and Paradigms - <http://au.wiley.com/WileyCDA/WileyTitle/productCd-0470887990.html>



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 pursuing a Masters in Distributed Computing (MEDC) at the University of Melbourne in July 2008, I was employed at IFS R&D, an ERP software vendor, since 2000. 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. In August 2009 after completing my degree, I joined the group as a full-time Research Fellow.



Throughout the year 2010 I continued to work on the Aneka platform, designing and implementing a number of features. Fault-tolerance through redundancy is a key feature in any distributed computing platform. I worked on implementing a multi-master failover mechanism for Aneka that employed the Bully Election algorithm to deterministically select an active master with a group of masters in the event of failure. This design was based on the mechanism used in the popular Oracle Grid Engine. I also made a few optimizations on the platform which reduced the data transferred for tasks on the platform by an order of magnitude resulting in lower latency, increased bandwidth efficiency and overall throughput of the system. Capturing analytical data is vital in grid and cloud platforms giving useful insights on a number of aspects including the execution of applications, performance bottlenecks, failures, data transfers and resource utilization. I spent a fair amount of time implementing and integrating monitoring and reporting services in the platform which provided a means to capture such real-time data while applications were being executed.

Other areas that I worked on include securing communication within a group of Aneka containers in the network. The platform currently uses symmetric-key encryption where the key is preconfigured on all nodes that will form part of the Cloud. In future, the shared key will be exchanged at runtime using public-key cryptography. I also added support for: staging files from Amazon S3 repositories; managing and installing Aneka Daemons and Containers on Linux systems; began implementation for Share File Systems in order to better support running Aneka on clusters; certifying Aneka on HP clusters and Windows Server 2008 RC2; releasing Aneka 2.0 (a major release since Aneka 1.0 in the previous year) and engaged with customers and individuals interested in the platform. I also contributed to the following publications.

C. Vecchiola, R. N. Calheiros, D. Karunamoorthy, R. Buyya "Provisioning Resources for Scientific Applications in Hybrid Clouds with Aneka", Utility and Cloud Computing 2010 (UCC 2010), December 14-16, 2010, Chennai, India. An extended version of this paper was submitted to a special issue on FGCS.

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)

Member Self Profile: Dr. Bahman Javadi

In June 2010, I entered into my new role as a Research Fellow in the CLOUDS Lab appointed to work on the ARC Discovery Project “InterGrid: Peering Architecture and policies for Internetworking Disparate Grids”. This project aims to provide a software system that allows the creation of execution environments for various applications on top of the physical infrastructure provided by the participating Grids. The allocation of resources from multiple Grids to fulfill the requirements of the execution environments is enabled by peering arrangements established between gateways.

Since I join the CLOUDS lab, I mainly worked on the reliability issues in the InterGrid where there is ability to borrow some resources from public Cloud providers. To do so, I developed a simulation environment in GridSim with ability to simulate resource failures from Failure Trace Archive (FTA). I also developed a new package in GridSim for a workload model of cluster systems (i.e. DAS-2 system). Both packages and related documents have been released as part of GridSim 5.2 in November 2010.



Before joining the CLOUDS lab, I was a post-doctoral fellow in MESCAL team at INRIA, Grenoble, France. I have been working on following projects during 2008-2010:

1. Clouds@home: A project funded by the national French science foundation (called ANR) for running complex services and applications over unreliable (Internet) resources. This project is in collaboration with the INRIA MOAIS, GRAAL and Grand-Large teams, and also UC Berkeley.
2. Failure Trace Archive: FTA is a centralized public repository of availability traces of parallel and distributed systems, and tools for their analysis. The purpose of this archive is to facilitate the design, validation, and comparison of fault-tolerant models and algorithms. This effort is in collaboration with INRIA Bordeaux and TU Delft. The project is funded by an INRIA project called ALEAE. (website: <http://fta.inria.fr>)

For the list of publications and details about my past and current work, please visit my webpage: <http://people.eng.unimelb.edu.au/bahmanj>

Member Self Profile: Rodrigo N. Calheiros

I joined the CLOUDS Lab as a Research Fellow in June 2010, after being a research visitor between 2008 and 2009. My main duties are related to the InterCloud project¹, which aims at developing an architecture and system for Federation of Clouds, comprising Brokers (acting on behalf of users), Cloud providers (including IaaS, PaaS, and SaaS providers), and a Cloud Exchange which mediates interaction between parties. So far, I have focused in two different aspects of the project: (I) development of the InterCloud software, and (II) development of resource provisioning policies. For the first aspect, previous work from the group (including InterGrid) is being used, together with a new service-oriented architecture for InterCloud. For the second aspect, I've been researching provisioning approaches based on performance modelling and workload prediction in a single data center level.



During my previous visit to the CLOUDS Lab, I worked in the CloudSim project, and also contributed in related works such as CloudAnalyst². Therefore, I still collaborating in the support for these tools whenever users from these tools contact us. I've been also involved in collaborations with researchers from Vienna University of Technology (Austria) and from Pontifical Catholic University of Rio Grande do Sul (Brazil) in a work related to management of Cloud infrastructures.

Before joining the group, I received my PhD degree from the Pontifical Catholic University of Rio Grande do Sul (PUCRS), working with virtualization-supported distribution systems emulation³.

My research interest include Cloud Federation, Resource Management in Clouds and Grids, Simulation, Emulation, and Virtualization.

1. R. Buyya, R. Ranjan, and R. N. Calheiros. *InterCloud: Utility-Oriented Federation of Cloud Computing Environments for Scaling of Application Services*. In 10th International Conference on Algorithms and Architectures for Parallel Processing (ICA3PP), 2010.
2. B. Wickremasinghe, R. N. Calheiros, and R. Buyya. *CloudAnalyst: A CloudSim-based Visual Modeller for Analysing Cloud Computing Environments and Applications*. In 24th IEEE International Conference on Advanced Information Networking and Applications (AINA), 2010.
3. R. N. Calheiros, R. Buyya, and C. A. F. De Rose. *Building an automated and self-configurable emulation testbed for grid application*. *Software: Practice and Experience*, 40(5):405-429, 2010.

Member Self Profile: Saurabh Kumar Garg



I am currently working as Research Fellow under the supervision of Dr. Rajkumar Buyya in Grid Computing and Distributed Systems (GRIDS) Laboratory of The University of Melbourne. 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 have been awarded with various scholarships such as Nicta-Topup Scholarship, MIFRS, and MIRS for my PhD candidature.

After joining GRIDS Laboratory, I conducted research in various research areas of Grid computing such as utility and market principles in grid computing, SLA based resource allocation, Meta-Scheduling etc. 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 have developed up to now 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, Virtualization and energy consumption of infrastructure.

During year 2010, I have proposed various scheduling policies^{1, 2} in Clouds. These works are submitted and published in to International Journals.

¹Linlin Wu, **Saurabh Kumar Garg**, and Rajkumar Buyya, [SLA-based Admission Control for a Software-as-a-Service Provider in Cloud Computing Environments](#), Technical Report, CLOUDS-TR-2010-7, Cloud Computing and Distributed Systems Laboratory, The University of Melbourne, Australia, September 20, 2010.

²(*)**Garg S. K.**, Buyya R., and Siegel H. J.,
“<http://www.engr.colostate.edu/~hj/conferences/296.pdf>Time and Cost Trade-off Management for Scheduling Parallel Applications on Utility Grids,” *Future Generation Computer Systems*, Volume 26, Number 8, Pages: 1344-1355, 2010. (ARC ERA Tier = A).

Member Self Profile: Suraj Pandey

I am a PhD student 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 2010 has been very productive for me.



I submitted my PhD thesis titled: "Scheduling and Management of Data Intensive Application Workflows in Grid and Cloud Computing Environments". I received an educational grant of \$US 6000 from Amazon AWS for software demonstrations using Amazon Clouds. The Victorian Life Sciences Computation Initiative (VLSCI) sponsored my travel to SC10, New Orleans, November 15-18, 2010, for presenting my work. I demonstrated my research work and software development at the Third IEEE International Scalable Computing Challenge (SCALE 2010), which was held in conjunction with the 10th IEEE International Symposium on Cluster, Cloud and Grid Computing (CCGrid 2010), Melbourne, Australia / May 17-20, 2010.

I supervised two Masters students in their final year projects. They are:

1. Sheng Niu, An Auto-scaling Cloud Computing Infrastructure based on Aneka Enterprise Middleware and Gridbus Workflow Engine, Masters of Engineering in Distributed Computing Project, University of Melbourne, June 2010.
2. ShivaKumar Buyya, Applications Scheduling and Management System for Cloud Infrastructure, Major Project (CS-899), Department of Computer Engineering, NITK, Surathkal, India, April 2010.

My publications, including a Best Paper award, are as follows:

1. 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.
2. Suraj Pandey, Linlin Wu, Siddeswara Guru, and Rajkumar Buyya, A Particle Swarm Optimization (PSO)-based Heuristic for Scheduling Workflow Applications in Cloud Computing Environments, Proceedings of the 24th IEEE International Conference on Advanced Information Networking and Applications (AINA 2010), Perth, Australia, April 20-23, 2010. - **Best Paper Award**.
3. Suraj Pandey, Kapil Kumar Gupta, Adam Barker and Rajkumar Buyya, Minimizing Execution Cost when using Globally Distributed Cloud Services, Proceedings of the 24th IEEE International Conference on Advanced Information Networking and Applications (AINA 2010), Perth, Australia, April 20-23, 2010.
4. Suraj Pandey, Personal Health Monitoring based on Mobile and Cloud Computing, Early Adopters PhD Workshop (EAPW) as part of the ACM/IEEE Supercomputing Conference 2010 (SC10), November 13-19, 2010, New Orleans, LA, USA.
5. Suraj Pandey, Scheduling Data Intensive Applications based on Multi-Source Parallel Data Retrievals, PhD Showcase, ACM/IEEE Supercomputing Conference 2010 (SC10), November 13-19, 2010 New Orleans, LA, USA.
6. Suraj Pandey, Rajkumar Buyya, Cloudbus Workflow Management System as a Platform-as-a-Service for Cloud Computing, Cloud Computing Virtual Conference (CloudSlam'10), March 23-25, 2010. PDF
7. Suraj Pandey, Rajkumar Buyya. Data-Intensive Scientific Applications on Clouds, TCSC Newsletter Volume 10, No.1, 2010.
8. Rajkumar Buyya, Suraj Pandey Feature - Cloudbus: A tool for utility-oriented cloud computing, International Science Grid This Week (iSGTW), February 3, 2010.

Member Self Profile: William Voorsluys

I joined CloudsLab 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 taking advantage of live migration and replication 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. I'm also working on fault tolerant policies to allow executing high performance computing application on variable pricing cloud resource (spot market).

My achievements in 2010 included: the publication of the first chapter of the book "*Cloud Computing: Principles and Paradigms*", which is a survey of Cloud Computing technologies; a application-oriented work on ECG monitoring and analysing using cloud computing; and the advancement of my PhD studies towards the interesting topic of variable pricing cloud resources in high performance computing, which will yield results in 2011.

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, 2011.

Member Self Profile: Anton Beloglazov



My name is Anton 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 the development of 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, an open-source Java framework for modeling and simulation of Cloud computing infrastructures and services.

In 2010, I have been awarded an internship at IBM Research India and spent three month in Bangalore working on a framework for IT service delivery simulation models. The research has aimed at understanding a variety of IT service delivery contexts and simulation models, extracting common elements, and implementing a library of reusable parts, to demonstrate the feasibility of this approach and its efficiency in generating new models of service variants. The work has leveraged the initial models created by the IBM Research teams in Watson and India and resulted in a product line structure for the family of models required by IBM's Global Delivery teams.

In 2010, I have completed 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 four main management levels: hardware and firmware, operating system, virtualization and data center levels. The paper has been accepted to "Advances in Computers" edited by M. Zelkowitz. In 2010, my research work on energy-efficient dynamic consolidation of virtual machines has resulted in the following publications:

1. Kyong Hoon Kim, Anton Beloglazov, and Rajkumar Buyya, "Power-Aware Provisioning of Virtual Machines for Real-time Cloud Services", Concurrency and Computation: Practice and Experience, ISSN: 1532-0626, Wiley Press, New York, USA, 2011 (in press, accepted on December 30, 2010)
2. Anton Beloglazov, and Rajkumar Buyya, "Energy-Efficient Consolidation of Virtual Machines in Cloud Data Centers", Proceedings of the IBM Collaborative Academia Research Exchange Workshop (I-CARE 2010), Bangalore, India, October 22, 2010
3. Anton Beloglazov, and Rajkumar Buyya, "Adaptive Threshold-Based Approach for Energy-Efficient Consolidation of Virtual Machines in Cloud Data Centers", Proceedings of the 8th International Workshop on Middleware for Grids, Clouds and e-Science (MGC 2010), Bangalore, India: ACM, November 29 – December 3, 2010
4. Anton Beloglazov, Rajkumar Buyya, Young Choon Lee, and Albert Zomaya, "A Taxonomy and Survey of Energy-Efficient Data Centers and Cloud Computing Systems", Advances in Computers, M. Zelkowitz (editor), ISBN 13: 978-0-12-012141-0, Elsevier, 2011.
5. Rajkumar Buyya, Anton Beloglazov, and Jemal Abawajy, "Energy-Efficient Management of Data Center Resources for Cloud Computing: A Vision, Architectural Elements, and Open Challenges", Proceedings of the 2010 International Conference on Parallel and Distributed Processing Techniques and Applications (PDPTA 2010), Las Vegas, USA, July 12-15, 2010

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

Member Self Profile: Amir Vahid Dastjerdi

I am a second year PhD student, and conducting my research on “QoS-aware Service Deployment in Federated Clouds” under supervision of Prof. Rajkumar Buyya. In year ten 2010, I have been mainly studying optimization techniques and QoS management for web service selection which was resulted in a book chapter that is a taxonomy and survey of QoS management and service selection methodologies for Cloud Computing. Then, I have applied those techniques to find a way to deploying network of virtual appliances across multiple clouds. That work was completed and was submitted to CCGRID 2011 conference. In addition, i attended



2010 EII PhD School in Brisbane, where I have met students in the same area of research and enjoyed discussing our research problems and have also fun visiting some of other friends in ZOO(as depicted)!! My publication in year 2010 comes below:

Conference papers:

1. Amir Vahid Dastjerdi, Sayed Tabatabaei, and Rajkumar Buyya, An Effective Architecture for Automated Appliance Management System Applying Ontology-Based Cloud Discovery, Proceedings of the 10th IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGrid 2010), Melbourne, Australia, May 17-20, 2010.
2. Amir Vahid Dastjerdi, Saurabh Kumar Garg, and Rajkumar Buyya , QoS-based Service Selection for Deploying Network of Virtual Appliances across Multiple Clouds, submitted to CCGrid 2011.

Book chapter:

1. Amir Vahid Dastjerdi and Rajkumar Buyya , "A Taxonomy and Survey of QoS Management and Service Selection Methodologies for Cloud Computing", Lizhe Wang, Rajiv Ranjan, Jinjun Chen, Boualem Benatallah, CRC, Taylor & Francis group (in press for Jun 2011, accepted on 23 Jan 2011)

Member Self Profile: Michael Mattess

I joined the CLOUDS lab at the beginning of 2008, when I commenced my masters by research at The University of Melbourne under the supervision of Professor Rajkumar Buyya. With this I returned to the department where I completed my undergraduate studies. During this Bachelor of Computer Science (with Honors) I investigated file systems and storage layer aspects of email systems.

Between the bachelor degree and commencing my masters I worked as a Software Engineer. In this role I develop an embedded system for the healthcare sector, which allowed for the integration of multiple systems found in hospitals. I also worked, amongst other things, on an IP based TV system.

For the most part of 2009 I was on leave-of-absence from my masters and worked as a consultant performing a diverse range of tasks. From building a virtualization cluster to reverse engineering legacy systems to writing a data migration application.

During 2010 I continued my research work, which is centered on the problems of offloading some processing of tasks to commercial cloud providers when the local infrastructure is overloaded. In late 2009 Amazon introduced 'Spot Instances', which have a varying, market driven price. Spot Instances were incorporated into my work, which was presented¹ at the HPCC 2010 conference. This work was then further extended and additional workloads were investigated.

At the end of 2010 I also converted from a masters by research degree to a PhD. In 2011 entering the third year of the PhD as a confirmed candidate.

[1] M. Mattess, C. Vecchiola, R. Buyya, Managing peak loads by leasing cloud infrastructure services from a spot market, in: High Performance Computing and Communications (HPCC), 2010 12th IEEE International Conference on, 2010, pp. 180 –188. doi:10.1109/HPCC.2010.77.



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 preemption-based resource provisioning in resource sharing environments such as InterGrid.

During 2009 and 2010, 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. The research paper resulted from this study was accepted and going to be published in Australian Computer Science Week 2011 Conference in Perth, Australia.

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. The research paper resulted from this study has been submitted to Cluster Cloud and Grid conference (CCGRID2011) in US.

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: Linlin Wu

Linlin Wu is a PhD candidate under the supervision of Professor Rajkumar Buyya in the CLOUDS Laboratory at the University of Melbourne, Australia. She received Master of Information Technology from the University of Melbourne and then worked for CA (Computer Associates Pty Ltd) as Quality Assurance Engineer. Then she joined National Australia Bank (NAB) as a Knowledge Optimization Officer. Here in Melbourne University, she has been awarded with APA scholarship supporting PhD studies. She received the Best Paper Award from AINA 2010 conference for her first publication. Her current research interests including: Service Level Agreement, QoS measurement, Resource Allocation, and Market-oriented Cloud computing. She is the Vice Chair of IEEE committee at the University of Melbourne organizing industry and social activities for IEEE members.



Publications:

1. Linlin Wu, Saurabh Kumar Garg, and Rajkumar Buyya, SLA-oriented Resource Allocation for a Software-as-a-Service Provider in Cloud Computing Environments, Technical Report, CLOUDS-TR-2010-8, Cloud Computing and Distributed Systems Laboratory, The University of Melbourne, Australia, December 07, 2010.
2. Linlin Wu, Saurabh Kumar Garg, and Rajkumar Buyya, [SLA-based Admission Control for a Software-as-a-Service Provider in Cloud Computing Environments](#), Technical Report, CLOUDS-TR-2010-7, Cloud Computing and Distributed Systems Laboratory, The University of Melbourne, Australia, September 20, 2010.
3. Linlin Wu and Rajkumar Buyya, [Service Level Agreement \(SLA\) in Utility Computing Systems](#), Technical Report, CLOUDS-TR-2010-5, Cloud Computing and Distributed Systems Laboratory, The University of Melbourne, Australia, September 3, 2010.
4. Suraj Pandey, Linlin Wu, Siddeswara Guru, and Rajkumar Buyya, [A Particle Swarm Optimization \(PSO\)-based Heuristic for Scheduling Workflow Applications in Cloud Computing Environments](#), Proceedings of the 24th IEEE International Conference on Advanced Information Networking and Applications (AINA 2010), Perth, Australia, April 20-23, 2010. - **Best Paper Award**.

Member Self Profile: Adel Toosi

I started my PhD studies under supervision of Dr. Rajkumar Buyya in the Department of Computer Science and Software engineering at the University of Melbourne in July 2010. I received my B.Sc. degree in 2003 and M.Sc. degree in 2006 both in Computer Software Engineering from Ferdowsi University of Mashhad, Iran. Throughout my master degree, I mainly focused on the areas of network security, especially intrusion detection systems, and soft computing system such as fuzzy systems and genetic algorithms.

Before coming to Melbourne, I was working in Azad University of Mashhad as a lecturer, which I was responsible for teaching courses like Internet Engineering, Formal Languages and Automata Theory. During that time, I found various aspects of distributed systems fascinating so I decided to continue my education in this area. Finally, I joined the CLOUDS Lab to pursue my PhD studies. My PhD studies are funded by Melbourne International Research Scholarship (MIRS) and Melbourne International Fee Remission Scholarship (MIFRS).



Currently, I am studying different aspects of Cloud Federation particularly economic and market oriented issues to characterize my PhD thesis topic. My research interest is developing advanced reservation based on real option pricing in Cloud Federation. After joining CLOUD lab, I have contributed to the development of the InterCloud project, which is a service-oriented framework for Cloud Federation. During last 6 months of 2010, my contribution to this project can be summarized as follows:

1. Connecting Aneka (a platform-as-service Cloud Computing project) to InterCloud through new .Net connectors inside Aneka container.
2. Installing OpenNebula in local infrastructure and developing a Java interface for connecting InterCloud to OpenNebula resources.
3. Collaborating with Rodrigo N. Calheiros in writing codes and preparing experiments on an upcoming paper on InterCloud design and architecture.

For detail information about my current research and past publications, please visit my homepage:

<http://www.csse.unimelb.edu.au/~adeln>

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
- 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*).

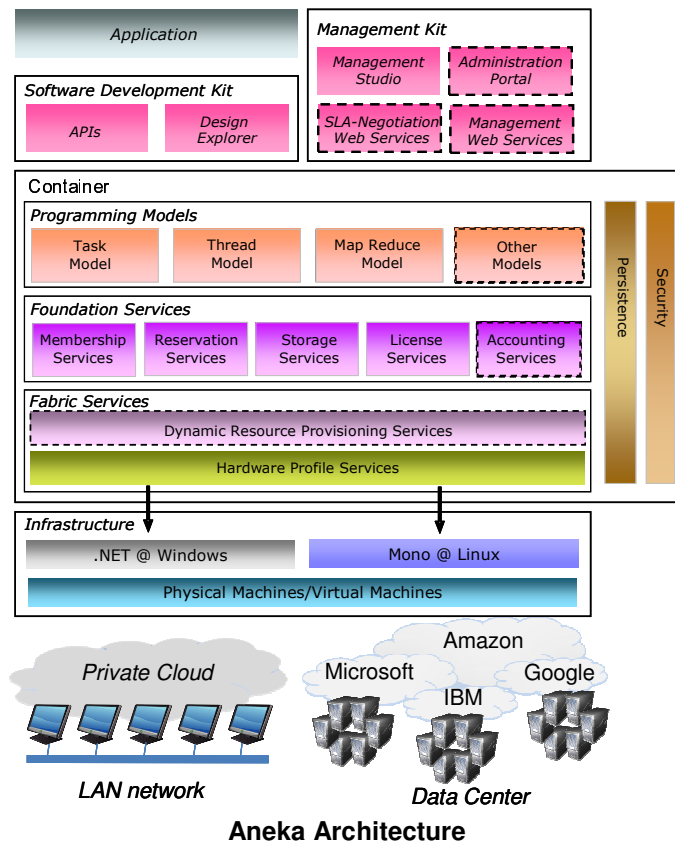
The software developed as part of the Gridbus Project has been released as open source, which enables practitioners around the world to benefit from the products of the Grid research, carried out at the University of Melbourne. The Grid software technologies developed by the Gridbus Project such as Gridbus 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:

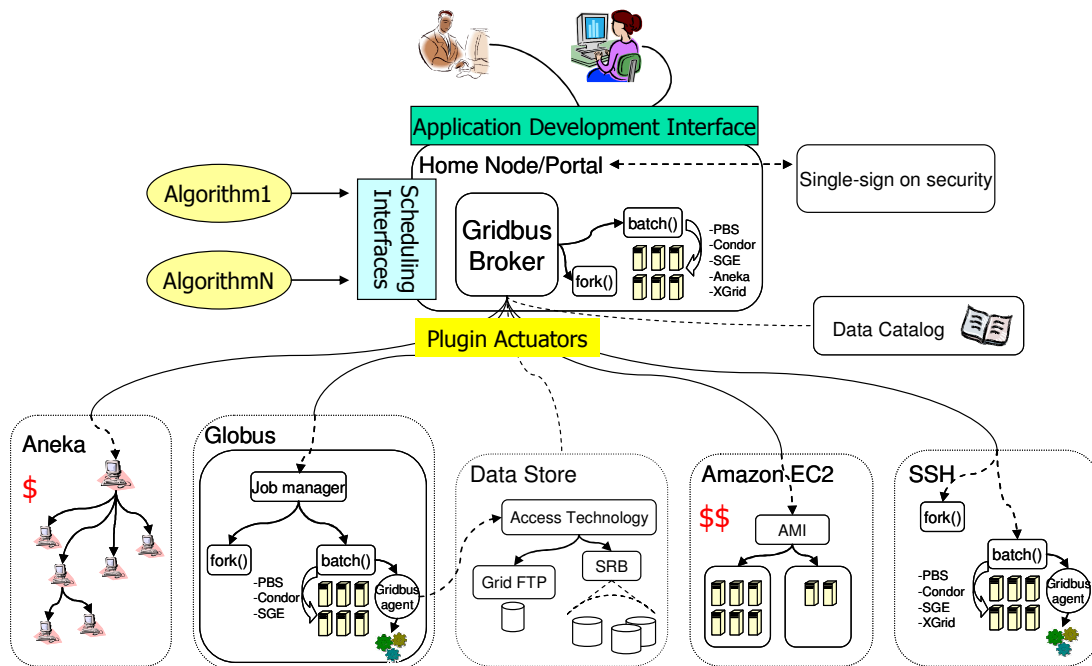
- A configurable and flexible execution platform (container) enabling -
 - Pluggable services;
 - Security implementations - multiple authentication / authorization mechanisms such as role-based security and Windows domain-based authentication;
 - Multiple persistence options including RDBMS, SQL Express, 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.cloudbus.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.

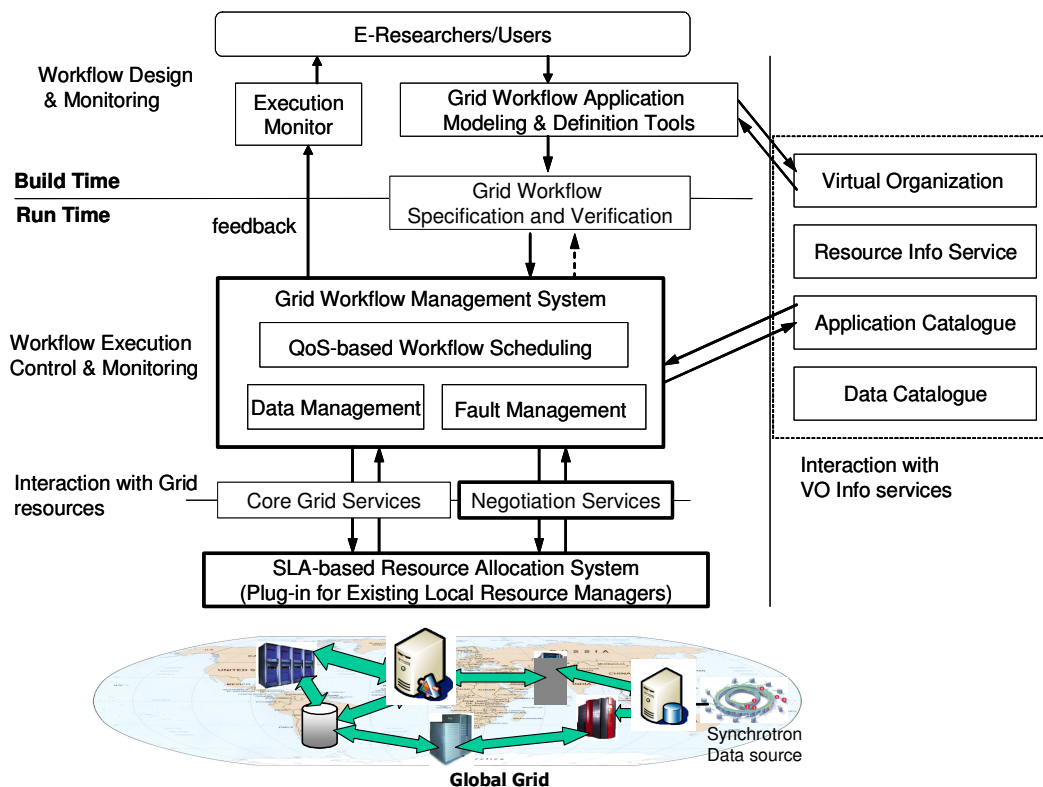


Fig. 1: Architecture of QoS-based workflow management and resource allocation system.

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.

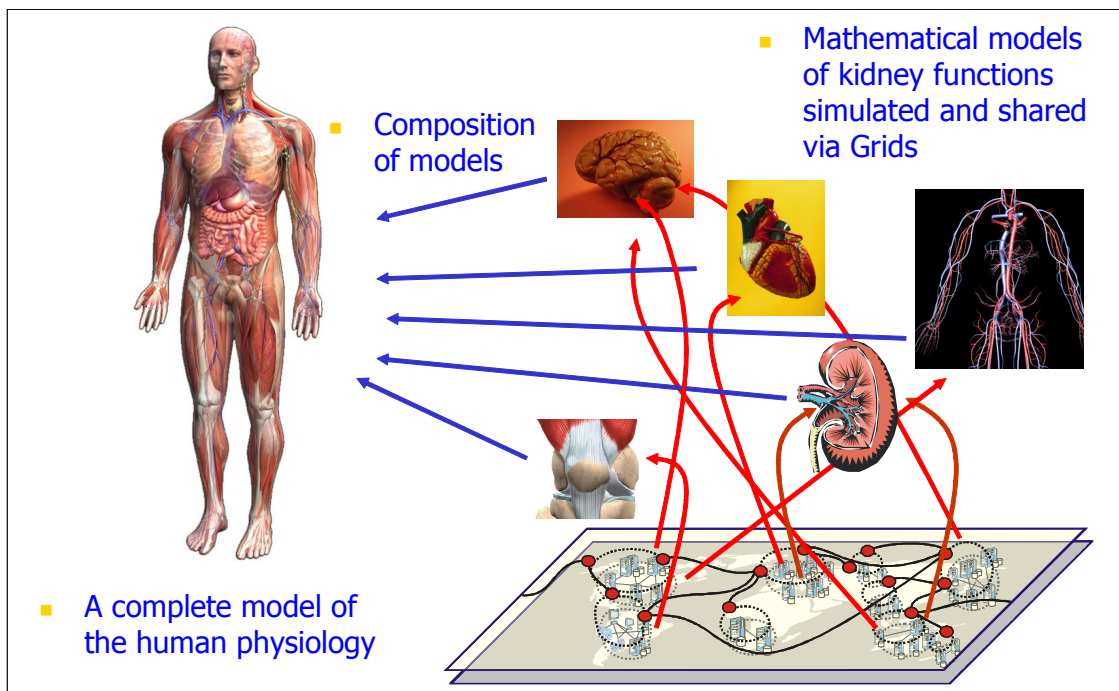


Fig. 1: InterGrid-based Integrated Human Physiome Environment.

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.

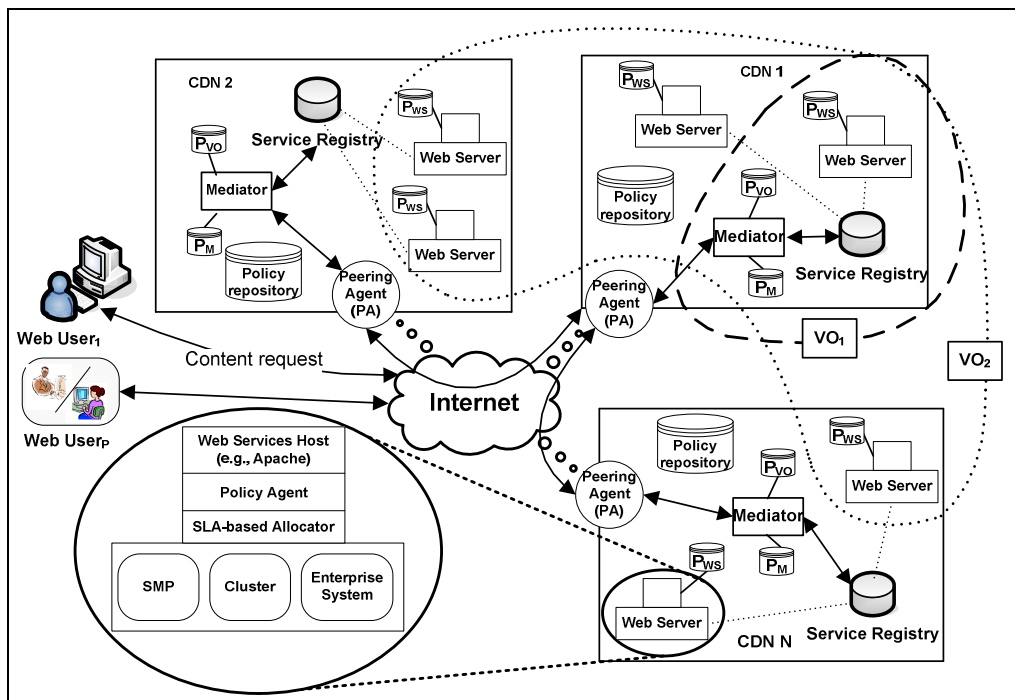


Fig. 1: Architecture of a system to assist the creation of internetworked CDNs

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 Enablement

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 5.2

The 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 5.2.

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

- A failure generator based on the Failure Trace Archive (FTA) format. The provided packages read the tabbed version of the failure traces and generate a list of events that show the availability/unavailability pattern for each machine in a grid resource. For more details, see the FTA web site (<http://fta.inria.fr>) and the following publication:
 - Derrick Kondo, Bahman Javadi, Alex Iosup, Dick Epema, The Failure Trace Archive: Enabling Comparative Analysis of Failures in Diverse Distributed Systems, In the 10th IEEE/ACM CCGrid, Melbourne, Australia, May, 2010.
- one allocation policy for scheduling of bag of tasks on cluster systems in the presence of resource failures.
- An implementation of the parallel jobs workload model of DAS-2 for modelling the workload of clusters. Details about the workload model are available in the following publication:
 - Hui Li, David Groep, and Lex Wolters, "Workload Characteristics of a Multi-cluster Supercomputer", LNCS 2005, Volume 3277/2005, 176-193.

The version 5.0 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. The allocation policies implemented are based on the following research papers:
 - Ahuva W. Mu'alem and Dror G. Feitelson, Utilization, Predictability, Workloads, and User Runtime Estimates in Scheduling the IBM SP2 with Backfilling. IEEE Transactions on Parallel and Distributed Systems, 12:(6), pp. 529-543, 2001.
 - Barry G. Lawson and Evgenia Smirni, Multiple-Queue Backfilling Scheduling with Priorities and Reservations for Parallel Systems, 2002 Workshop on Job Scheduling Strategies for Parallel Processing (JSSPP), pp. 72-87, 2002.
 - Srividya Srinivasan, Rajkumar Kettimuthu, Vijay Subramani, and Ponnuswamy Sadayappan. Selective Reservation Strategies for Backfill Job Scheduling. In JSSPP 2002, LNCS 2537, Springer-Verlag Berlin Heidelberg, pp. 55-71, 2002.
- An implementation of the workload model by Lublin and Feitelson for modelling the workload of clusters and supercomputers. Details about the workload model are available in the following publication:
 - Uri Lublin and Dror G. Feitelson, The Workload on Parallel Supercomputers: Modeling the Characteristics of Rigid Jobs. J. Parallel & Distributed Comput. 63(11), pp. 1105-1122, Nov 2003.
- 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.
- Bahman Javadi, CLOUDS Lab @ The University of Melbourne.

To download the GridSim software, please visit the CLOUDS Lab web site at

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

Join the GridSim mailing lists at

<http://sourceforge.net/projects/gridsim>

3. CloudSim Toolkit 2.0: A Framework For Modeling And Simulation Of Cloud Computing Infrastructures And Services

The Cloudbus Project at The University of Melbourne, Australia along with collaborators from the High Performance Lab (LAD) at Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, Brazil is proud to announce the release of the new version of its Cloud simulation software, the CloudSim.

One year has passed since CloudSim beta was released. Since then, Cloud computing has gained more visibility, and a plenty of new projects, both in academia and in the industry, emerged.

To help developers of such projects to evaluate new strategies and ideas before actual development, CloudSim 2.0 contains support for model and simulation of hot topics in Cloud Computing, including green/power-aware Cloud Computing and federated Cloud Computing.

At the same time new features were added, major improvements in simulation core allowed enhanced scalability and performance of simulations and insertion and removal of simulation entities during simulation execution. It increases considerably scenarios that may be addressed in simulations, what we hope will contribute to a wider adoption of the tool by the research community.

These improvements were possible due to extensive support from the Cloud Computing research community around the world, which used CloudSim, appointed bugs, and provided us feedback on new features they would like to have in future versions the toolkit. Community is invited to keep contribution to CloudSim.

As in its previous version, 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 our users.

To download the CloudSim software, please visit the Cloudbus Project web site at <http://www.cloudbus.org/cloudsim/>

Publications:

- Rodrigo N. Calheiros, Rajiv Ranjan, Anton Beloglazov, Cesar A. F. De Rose, and Rajkumar Buyya, [CloudSim: A Toolkit for Modeling and Simulation of Cloud Computing Environments and Evaluation of Resource Provisioning Algorithms](#), Software: Practice and Experience (SPE), Volume 41, Number 1, Pages: 23-50, ISSN: 0038-0644, Wiley Press, New York, USA, January, 2011.
- Bhathiya Wickremasinghe, Rodrigo N. Calheiros, Rajkumar Buyya, CloudAnalyst: A CloudSim-based Visual Modeller for Analysing Cloud Computing Environments and Applications, Proceedings of the 24th International Conference on Advanced Information Networking and Applications (AINA 2010), Perth, Australia, April 20-23, 2010.

4. Aneka 2.0: A Software Technology to Simplify .NET-based Enterprise Clouds

Manjrasoft Pty Ltd, Australia

Aneka is a Cloud Application Development Platform (CAP) for developing and running compute and data intensive applications. As a platform it provides users with both a runtime environment for executing applications developed using any of the three supported programming models, and a set of APIs and tools that allow you to build new applications or run existing legacy code. The purpose of this document is to help you through the process of installing and setting up an Aneka Cloud environment. This document will cover everything from helping you to understand your existing infrastructure, different deployment options, installing the Management Studio, configuring Aneka Daemons and Containers, and finally running some of the samples to test your environment.

The Aneka 2.0 distribution comes with the following features:

- Application Catalogue Service
 - Implemented Platform independent management protocol
 - Central software repository for software installation and update
 - Implemented Node gateway to control the node services
- Reservation Integration
 - Integrated Reservation services into Aneka codebase
 - Integrated the existing Allocation services into Aneka codebase
- Enterprise QoS
 - Added Cost-Optimization Job Scheduling
 - Added Time-Optimization Job Scheduling
 - Added User Modules into Design Explorer enabling selection of QoS
- Cloud Deployment
 - Full support for Amazon EC2 (static deployment and dynamic deployment)
 - Full support for Xen Virtualization
 - Static deployment via Xen VM: Dynamic deployment via Xen API
 - Full support for GoGrid (static deployment and dynamic deployment)
- Logging Service
 - Added logging service that manage the log information in each node
 - Added logging management GUI to view the log information
- Dynamic Resource Provisioning Scheduling
 - Added intelligent algorithm to dynamic provisioning service to auto scale the resources based on QoS
- Reporting Service
 - Provided service capability to report its own properties to the Aneka container
 - Implemented the Reporting service that handles queries related to various reporting activities including billing, metering, and usage
 - Enhanced GUI to provide statistics for various reporting activities
 - Configuration Utilities: Implemented customizable configuration facilities that will be used when configuring various Aneka services

Download:

<http://www.manjrasoft.com>

11. Moments with Visitors, Colleagues and International Hosts



CLOUDS Lab members (most of them) in front of the ICT building.



Suraj receiving the Best Paper Award at AINA 2010 Conference.



During Eureka Award Dinner in Sydney with Srikumar



A seminar in Korea University, Seoul