

Cloud Computing and Distributed Systems Laboratory and the Cloudbus Project



Annual Report - 2017



School of Computing and Information Systems

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 2017, which has been another extraordinary year in terms of research quality and international recognition of its members. The Lab has consolidated its position as one of the world-leaders in developing innovative solutions for Cloud Computing. The highlights of research activities and outcomes in 2017 are:



- The Lab successfully hosted two ARC research projects (Discovery and Linkage Projects) along with two industry funded projects.
- Members of the CLOUDS Lab have authored 54 publications, which include 31 journal papers and 11 conference papers.
- The Lab's flagship Cloudbus Project has released various new modules for Aneka, CloudSim and iFogSim. The iFogSim building on CloudSim is emerging as a de-facto Toolkit for modelling and simulation of Fog and Edge computing environments. It has been used by several researchers in academia and industries around the world.
- Members have presented over 40 invited talks that include 13 keynotes delivered at international conferences/seminars held in Australia, India, Indonesia, Mauritius, and UK.
- The Lab successfully hosted research activities of over 25 scholars, which include 16 PhD students and 4 Research Fellows.
- **"2017 Web of Science Highly Cited Researcher"** recognition from Thomson Reuters for a team member!
- In 2017 alone, our papers have attracted over 9600 citations (ref: Google Scholar) and we hope this trend will continue!
- The Lab housed several (short and long term) international visitors (academic and PhD students) from India, China, Germany, Estonia, and UK.
- Our Lab's spin-off company, Manjrasoft has been recognised as one of the Top 10 Most Valuable Cloud Solution Providers by the Insight Success Magazine.
- Members of the Lab have led community efforts such as (a) the organisation of conferences (e.g., UCC 2017 and BDC 2017 in USA) and (b) Co-Editor-In-Chief of Journal of Software: Practice and Experience, which was established 40+ years ago.

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!

Sincerely yours,

A handwritten signature in black ink, appearing to read 'Rajkumar Buyya'.

Professor Rajkumar Buyya, PhD
Director, Cloud Computing and Distributed Systems (CLOUDS) Laboratory
School of Computing and Information Systems
The University of Melbourne, Australia
Web: www.cloudbus.org

2. The Team

Director:

- Professor Rajkumar Buyya

Research Staff:

- Dr. Adel Toosi
- Dr. Maria Rodriguez
- Dr. Hasanul Ferdous
- Dr. Sukhpal Singh Gill

PhD Students

- Mr. Jungmin Jay Son
- Mr. Bowen Zhou
- Mr. Safiollah Heidari
- Mr. Xunyun Liu
- Mr. Jaydeep Das, Indian Institute of Technology, Kharagpur
- Mr. Caesar Wu
- Mr. Minxian Xu
- Ms. Sara Kardani Moghaddam
- Mr. Muhammad H. Hilman
- Mr. Redowan Mahmud
- Ms. Imairi Eitiveni
- Mr. Muhammed Tawfiqul
- Mr. Carlos Gomez, University of Birmingham, UK
- Ms. Maria Salama, University of Birmingham, UK
- Mr. Anit Khan, Monash University, Australia
- Mr. Shashikant Ilager
- Mr. TianZhang He

Collaborators

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

International Visitors

- Dr. Rajinder Sandhu, GND University, Amritsar, India, Jan-Aug 2017.
- Dr. Marcos Dias de Assuncao, INRIA, April and Nov 2017.
- Prof. Satish Narayana Srirama, University of Tartu, Estonia: April-Aug 2017.
- Ms. Kashish Ara Shakil, Jamia Millia Islamia, Delhi, India, June-Aug 2017.
- Prof. Giuliano Casale, Imperial College London, UK, August 2017.
- Prof. Gleb Radchenko, South Ural State University, Russia, September 2017.
- Dr. Dawei Sun, China University of Geosciences, Beijing, China, May-Nov. 2017.
- Mr. Arash Shaghghi, University of New South Wales, Sydney, Australia, Aug-Dec. 2017.
- Mr. Ehsan Nadjaran Toosi, Germany, Nov 2017-Jan 2018.

3. Competitive Grants Funded Projects and Programs - Active

Australian Research Council (ARC)

- R. Kotagiri, R. Buyya, C. Leckie, and S. Versteeg, Business goals and analytics driven management of cloud computing based information technology infrastructure, Linkage Project, ARC, 2013-2016. Amount: \$280,000.
- R. Buyya, Algorithms and Software Systems for Management of Software-Defined Clouds, Discovery Project, Australian Research Council (ARC), 2016-2020. Amount: \$410,000.

Other National Grants

- R. Ranjan, R. Buyya, R. Shyamasundar, A. Zaslavsky, S. Nepal, R. Calheiros, S. Chen, R. Ghosh, A. Haller, and O. Dabeer, "Innovative Solutions for Deployment of BigData and Disaster Management Applications on Clouds", Australia-India Strategic Research Fund (AISRF Round 7), Australian Department of Industry, 2013-2017. Amount: \$400,000.
- Indian partners received direct funding from Dept. of Science and Technology (DST), Govt. Of India. Amount: INR 10,200,000.

Industry and Melbourne University Grants

- R. Buyya, Z. Xiao, Y. Cui, Y. Wu, J. Cao, U. Bellur, R. K. Shyamasundar, R. K. Pisipati, B. Sinha, S. K. Nandy, J. Lakshmi, and T. V. Prabhakar, "Melbourne-Chindia Cloud Computing (MC3) Research Network", International Research and Research Training Fund (IRRFTF), The University of Melbourne, 2013-2017. Amount: \$150,000.
 - R. Buyya and A. Vahid, "Data Science for Enabling Prediction and Classification of Pedestrians Flows in Melbourne City", Academic Research Grant-Equipment Access, Microsoft, Seattle, USA, 2015-2017. Amount Equivalent: Approx. US\$20,000.
 - R. Buyya and M. Assuncao, Algorithms for Placement and Reconfiguration of Data Stream Processing Services for IoT Applications, French National Centre for Scientific Research (CNRS)-Melbourne University Cooperation, The University of Melbourne, Australia, 2017-2018. Amount: \$10,000.
 - R. Buyya, "Auto-Scaling and Resource Coordination of Network Slices in Software-Defined Clouds", Huawei Innovation Research Program (HIRP), Huawei, China, Sept. 2017-2018. Amount: US\$75,000 (~A\$100,000).
 - R. Buyya, A. Toosi, and M. Sossa, "Cost-Efficient Orchestration of Containers in Clouds", Global Research Outreach (GRO) Program, Samsung, South Korea, Oct. 2017-2018. Amount: US\$120,000 (~A\$150,000).
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4. Publications

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

Year Publication Type	2002	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17
Books/Proceedings (Authored/Edited)	1	1	1	1	5	4	3	5	2	3	2	2	1	2	3	1
Journal Papers	6	1	4	5	6	4	10	13	8	9	15	17	17	17	24	31
Book Chapters	1	0	0	4	4	2	4	11	3	13	3	1	2	3	6	10
Conference Papers	4	7	9	16	15	24	22	27	15	14	12	6	14	21	9	11
Magazine Articles	0	0	1	2	4	2	0	1	2	1	0	5	2	3	1	1
<i>Total</i>	12	9	15	28	34	36	39	57	30	40	32	31	36	46	43	54

Books/Proceedings Edited

- Sanjay Chaudhary, Gaurav Somani, and Rajkumar Buyya (eds.), Research Advances in Cloud Computing, 465 pages, ISBN: 978-981-10-5026-8, Springer, Singapore, December 2017.

Book Chapters

- Atefeh Khosravi and Rajkumar Buyya, Energy and Carbon Footprint-Aware Management of Geo-Distributed Cloud Data Centers: A Taxonomy, State of the Art, and Future Directions, Advancing Cloud Database Systems and Capacity Planning With Dynamic Applications, N. Kamila (editor), 27-46pp, ISBN13: 9781522520139, IGI Global, Hershey, PA, USA, January 2017.
- Harshit Gupta, Sandip Chakraborty, Soumya K. Ghosh, and Rajkumar Buyya, Fog Computing in 5G Networks: An Application Perspective, Cloud and Fog Computing in 5G Mobile Networks, E. Markakis, G. Mastorakis, C. Mavromoustakis, E. Pallis (eds.), ISBN: 978-1-78561-083-7, IET (Institution of Engineering and Technology) Press, Hertfordshire, UK, 2017.
- Xinwei Zhao, Saurabh Garg, Carlos Queiroz, and Rajkumar Buyya, A Taxonomy and Survey of Stream Processing Systems, Software Architecture for Big Data and the Cloud, I. Mistrik, R. Bahsoon, N. Ali, M. Heisel, and B. Maxim (eds), 183-206, ISBN: 9780128054673, Morgan Kaufmann, Burlington, Massachusetts, USA, June 2017.
- Deepak Poola, Mohsen Amini, Kotagiri Ramamohanarao, and Rajkumar Buyya, A Taxonomy and Survey of Fault-Tolerant Workflow Management Systems in Cloud and Distributed Computing Environments, Software Architecture for Big Data and the Cloud, I. Mistrik, R. Bahsoon, N. Ali, M. Heisel, and B. Maxim (eds), 285-320, ISBN: 9780128054673, Morgan Kaufmann, Burlington, Massachusetts, USA, June 2017.
- Maria A. Rodriguez and Rajkumar Buyya, Scientific Workflow Management System for Clouds, Software Architecture for Big Data and the Cloud, I. Mistrik, R. Bahsoon, N. Ali, M. Heisel, and B. Maxim (eds), 357-387pp, ISBN: 9780128054673, Morgan Kaufmann, Burlington, Massachusetts, USA, June 2017.
- Md Anit Khan, Andrew Paplinski, Abdul Malik Khan, Manzur Murshed, and Rajkumar Buyya, Dynamic Virtual Machine Consolidation Algorithms for Energy-Efficient Cloud Resource Management: A Review, Sustainable Cloud and Energy Services: Principles and Practice, W. Rivera (editor), 135-165pp, ISBN 978-3-319-62238-5, Springer, USA, September 2017.
- Atefeh Khosravi and Rajkumar Buyya, Short-Term Prediction Model to Maximize Renewable Energy Usage in Cloud Data Centers, Sustainable Cloud and Energy

- Services: Principles and Practice, W. Rivera (editor), 203-218pp, ISBN 978-3-319-62238-5, Springer, USA, September 2017.
9. Redowan Mahmud, Kotagiri Ramamohanarao, and Rajkumar Buyya, Fog Computing: A Taxonomy, Survey and Future Directions, Internet of Everything: Algorithms, Methodologies, Technologies and Perspectives, B. DiMartino, K. Li, L. Yang, A. Esposito (eds), 103-130pp, ISBN 978-981-10-5860-8, Springer, Singapore, October 2017.
 10. Adel Nadjaran Toosi and Rajkumar Buyya, Virtual Networking with Azure for hybrid Cloud Computing in Aneka, Research Advances in Cloud Computing, S. Chaudhary, G. Somani, and R. Buyya (eds), ISBN: 978-981-10-5026-8, Springer, Singapore, December 2017.
 11. Nikolay Grozev and Rajkumar Buyya, Dynamic Selection of Virtual Machines for Application Servers in Cloud Environments, Research Advances in Cloud Computing, S. Chaudhary, G. Somani, and R. Buyya (eds), ISBN: 978-981-10-5026-8, Springer, Singapore, December 2017.

Journal Editorials

12. Meikang Qiu, Saurabh Garg, Rajkumar Buyya, Bei Yu, and Shiyan Hu, Special Issue on Scalable Cyber-Physical Systems, Journal of Parallel and Distributed Computing, Volume 103, Pages: 1-2, ISSN: 0743-7315, Elsevier Press, Amsterdam, The Netherlands, May 2017.
13. Rajiv Ranjan, Dhavalkumar Thakker, Armin Haller, and Rajkumar Buyya, A Note on Exploration of IoT Generated Big Data using Semantics, Future Generation Computer Systems, Volume 76, Pages: 495-498, ISSN: 0167-739X, Elsevier Press, Amsterdam, The Netherlands, November 2017.
14. Arun Agarwal and Rajkumar Buyya, Special Issue on Cloud Computing for Scientific and Business Needs, CSI Transactions on ICT, Volume 5, No. 4, Pages: 339-339, Springer, India, December 2017.

Journal Papers

15. Chii Chang, Satish Narayana Srirama, and Rajkumar Buyya, Mobile Cloud Business Process Management System for the Internet of Things: A Survey, ACM Computing Surveys, Volume 49, No. 4, Article No. 70, Pages: 1-42, ISSN 0360-0300, ACM Press, New York, USA, January 2017.
16. Fabio D. Rossi, Miguel G. Xavier, Cesar A.F. De Rose, Rodrigo N. Calheiros, Rajkumar Buyya, E-eco: Performance-Aware Energy-Efficient Cloud Data Center Orchestration, Journal of Network and Computer Applications (JNCA), Volume 78, Pages: 83-96, ISSN: 1084-8045, Elsevier, Amsterdam, The Netherlands, January 2017.
17. Gaurav Somani, Manoj Singh Gaur, Dheeraj Sanghi, Mauro Conti, Muttukrishnan Rajarajan, and Rajkumar Buyya, Combating DDoS Attacks in Cloud: Requirements, Trends, and Future Directions, IEEE Cloud Computing, Volume 4, No. 1, Pages: 22-32, ISSN: 2325-6095, IEEE Computer Society Press, USA, Jan.-Feb. 2017.
18. Hao Sun, Xiaofeng Wang, Rajkumar Buyya, and Jinshu Su, CloudEyes: Cloud-based Malware Detection with Reversible Sketch for Resource-constrained Internet of Things(IoT) Devices, Software: Practice and Experience, Volume 47, Number 3, Pages: 421-441, ISSN: 0038-0644, Wiley Press, New York, USA, March 2017.
19. Raghavendra Kune, Pramod Kumar Konugurthi, Arun Agarwal, Raghavendra Rao Chillarige, and Rajkumar Buyya, XHAMI - Extended HDFS and MapReduce Interface for Big Data Image Processing Applications in Cloud Computing Environments, Software: Practice and Experience, Volume 47, Number 5, Pages: 455-472, ISSN: 0038-0644, Wiley Press, New York, USA, March 2017.
20. Li Liu, Miao Zhang, Rajkumar Buyya and Qi Fan, Deadline-constrained Coevolutionary Genetic Algorithm for Scientific Workflow Scheduling in Cloud Computing, Concurrency

- and Computation: Practice and Experience (CCPE), Volume 29, No. 5, Pages: 1-12, ISSN: 1532-0626, Wiley Press, New York, USA, March 10, 2017.
21. Adel Nadjaran Toosi, Chenhao Qu, Marcos Dias de Assuncao, and Rajkumar Buyya, Renewable-aware Geographical Load Balancing of Web Applications for Sustainable Data Centers, *Journal of Network and Computer Applications (JNCA)*, Volume 83, Pages: 155-168, ISSN: 1084-8045, Elsevier, Amsterdam, The Netherlands, April 2017.
 22. Maria A. Rodriguez and Rajkumar Buyya, A Taxonomy and Survey on Scheduling Algorithms for Scientific Workflows in IaaS Cloud Computing Environments, *Concurrency and Computation: Practice and Experience (CCPE)*, Volume 29, No. 8, Pages: 1-23, ISSN: 1532-0626, Wiley Press, New York, USA, April 25, 2017.
 23. Sareh Fotuhi Piraghaj, Amir Vahid Dastjerdi, Rodrigo N. Calheiros, and Rajkumar Buyya, ContainerCloudSim: An Environment for Modeling and Simulation of Containers in Cloud Data Centers, *Software: Practice and Experience*, Volume 47, Number 4, Pages: 505-521, ISSN: 0038-0644, Wiley Press, New York, USA, April 2017.
 24. Deepsubhra Guha Roy, Debashis De, Anwesha Mukherjee, and Rajkumar Buyya, Application-aware Cloudlet Selection for Computation Offloading in Multi-Cloudlet Environment, *The Journal of Supercomputing*, Volume 73, Number 4, Pages: 1672-1690, ISSN: 0920-8542, Springer Science+Business Media, Berlin, Germany, April 2017.
 25. Luiz F. Bittencourt, Javier Diaz-Montes, Rajkumar Buyya, Omer F. Rana, and Manish Parashar, Mobility-aware Application Scheduling in Fog Computing, *IEEE Cloud Computing*, Volume 4, No. 2, Pages: 34-43, ISSN: 2325-6095, IEEE Computer Society Press, USA, March-April 2017.
 26. Maria A. Rodriguez and Rajkumar Buyya, Budget-Driven Scheduling of Scientific Workflows in IaaS Clouds with Fine-Grained Billing Periods, *ACM Transactions on Autonomous and Adaptive Systems (TAAS)*, Volume 12, Number 2, Article No.: 5, Pages: 1-22, ISSN: 1556-4665, ACM Press, New York, USA, May 2017.
 27. Patricia Arroba, Jose M. Moya, Jose L. Ayala, and Rajkumar Buyya, Dynamic Voltage and Frequency Scaling-aware Dynamic Consolidation of Virtual Machines for Energy Efficient Cloud Data Centers, *Concurrency and Computation: Practice and Experience (CCPE)*, Volume 29, No. 10, Pages: 1-13, ISSN: 1532-0626, Wiley Press, New York, USA, May 25, 2017.
 28. Chandrashekar Jatoth, G R Gangadharan, and Rajkumar Buyya, Computational Intelligence based QoS-aware Web Service Composition: A Systematic Literature Review, *IEEE Transactions on Services Computing (TSC)*, Volume 10, Number 3, Pages: 475-492, ISSN: 1939-1374, IEEE Computer Society Press, USA, May-June 2017.
 29. Gaurav Somani, Manoj Singh Gaur, Dheeraj Sanghi, Mauro Conti, and Rajkumar Buyya, Service Resizing for Quick DDoS Mitigation in Cloud Computing Environment, *Annals of Telecommunications*, Volume 72, No. 5, Pages: 237-252, ISSN: 0003-4347, Springer, Paris, France, June 2017.
 30. Minxian Xu, Wenhong Tian, and Rajkumar Buyya, A Survey on Load Balancing Algorithms for Virtual Machines Placement in Cloud Computing, *Concurrency and Computation: Practice and Experience (CCPE)*, Volume 29, No. 12, Pages: 1-16, ISSN: 1532-0626, Wiley Press, New York, USA, June 25, 2017.
 31. Chenhao Qu, Rodrigo N. Calheiros, and Rajkumar Buyya, Mitigating Impact of Short-term Overload on Multi-Cloud Web Applications through Geographical Load Balancing, *Concurrency and Computation: Practice and Experience (CCPE)*, Volume 29, No. 12, Pages: 1-15, ISSN: 1532-0626, Wiley Press, New York, USA, June 25, 2017.
 32. Jungmin Son, Amir Vahid Dastjerdi, Rodrigo N. Calheiros, and Rajkumar Buyya, SLA-aware and Energy-Efficient Dynamic Overbooking in SDN-based Cloud Data Centers, *IEEE Transactions on Sustainable Computing (T-SUSC)*, Volume 2, Number 2, Pages: 76-89, ISSN: 2377-3782, IEEE Computer Society Press, USA, June 2017.
 33. Atefeh Khosravi, Lachlan L. H. Andrew, and Rajkumar Buyya, Dynamic VM Placement Method for Minimizing Energy and Carbon Cost in Geographically Distributed Cloud Data Centers, *IEEE Transactions on Sustainable Computing (T-SUSC)*, Volume 2, Number 2, Pages: 183-196, ISSN: 2377-3782, IEEE Computer Society Press, USA, June 2017.

34. Gaurav Somani, Manoj Singh Gaur, Dheeraj Sanghi, Mauro Conti, and Rajkumar Buyya, DDoS Attacks in Cloud Computing: Issues, Taxonomy, and Future Directions, *Computer Communications*, Volume 107, Pages: 30-48, ISSN: 0140-3664, Elsevier Science, Amsterdam, The Netherlands, July 15, 2017.
35. Mehdi Sookhak, F. Richard Yu, Muhammad Khurram Khan, Yang Xiang, and Rajkumar Buyya, Attribute-Based Data Access Control in Mobile Cloud Computing: Taxonomy and Open Issues, *Future Generation Computer Systems*, Volume 72, Pages: 273-287, ISSN: 0167-739X, Elsevier Science, Amsterdam, The Netherlands, July 2017.
36. Thar Baker, Muhammad Asim, Hissam Tawfik, Bandar Aldawsari, Rajkumar Buyya, An Energy-aware Service Composition Algorithm for Multiple Cloud-based IoT Applications, *Journal of Network and Computer Applications (JNCA)*, Volume 89, Pages: 96-108, ISSN: 1084-8045, Elsevier, Amsterdam, The Netherlands, July 2017.
37. Asad Malik, Kashif Bilal, Saif Malik, Zahid Anwar, Khurram Aziz, Dzmity Kliazovich, Nasir Ghani, Samee Khan, and Rajkumar Buyya, CloudNetSim++: A GUI Based Framework for Modeling and Simulation of Data Centers in OMNeT++, *IEEE Transactions on Services Computing (TSC)*, Volume 10, Number 4, Pages: 506-519, ISSN: 1939-1374, IEEE Computer Society Press, USA, July/August 2017.
38. Harshit Gupta, Amir Vahid Dastjerdi, Soumya K. Ghosh, and Rajkumar Buyya, iFogSim: A Toolkit for Modeling and Simulation of Resource Management Techniques in Internet of Things, Edge and Fog Computing Environments, *Software: Practice and Experience (SPE)*, Volume 47, Issue 9, Pages: 1275-1296, ISSN: 0038-0644, Wiley Press, New York, USA, September 2017.
39. Atefeh Khosravi, Adel Nadjaran Toosi, and Rajkumar Buyya, Online Virtual Machine Migration for Renewable Energy Usage Maximization in Geographically Distributed Cloud Data Centers, *Concurrency and Computation: Practice and Experience (CCPE)*, Volume 29, No. 18, Pages: 1-13, ISSN: 1532-0626, Wiley Press, New York, USA, September 25, 2017.
40. Rodrigo N. Calheiros, Kotagiri Ramamohanarao, Rajkumar Buyya, Christopher Leckie, and Steve Versteeg, On the Effectiveness of Isolation-Based Anomaly Detection in Cloud Data Centers, *Concurrency and Computation: Practice and Experience (CCPE)*, Volume 29, No. 18, Pages: 1-12, ISSN: 1532-0626, Wiley Press, New York, USA, September 25, 2017.
41. Bowen Zhou, Amir Vahid Dastjerdi, Rodrigo N. Calheiros, Satish Narayana Srirama, and Rajkumar Buyya, mCloud: A Context-aware Offloading Framework for Heterogeneous Mobile Cloud, *IEEE Transactions on Services Computing (TSC)*, Volume 10, Number 5, Pages: 797-810, ISSN: 1939-1374, IEEE Computer Society Press, USA, Sept.-Oct. 1, 2017.
42. Leonard Heilig, Rajkumar Buyya, and Stefan Voß, Location-Aware Brokering for Consumers in Multi-Cloud Computing Environments, *Journal of Network and Computer Applications (JNCA)*, Volume 95, Pages: 79-93, ISSN: 1084-8045, Elsevier, Amsterdam, The Netherlands, October 2017.
43. Sukhpal Singh Gill, Inderveer Chana, and Rajkumar Buyya, IoT Based Agriculture as a Cloud and Big Data Service: The Beginning of Digital India, *Journal of Organizational and End User Computing*, Volume 29, No. 4, Pages: 1-23, ISSN: 1546-2234, IGI Global, Hershey, PA, USA, October-December 2017.
44. Md Hasanul Ferdaus, Manzur Murshed, Rodrigo N. Calheiros, and Rajkumar Buyya, An Algorithm for Network and Data-aware Placement of Multi-Tier Applications in Cloud Data Centers, *Journal of Network and Computer Applications (JNCA)*, Volume 98, Pages: 65-83, ISSN: 1084-8045, Elsevier, Amsterdam, The Netherlands, November 15, 2017.
45. Ao Zhou, Shangguang Wang, Bo Cheng, Zibin Zheng, Fangchun Yang, Rong N. Chang, Michael R. Lyu, and Rajkumar Buyya, Cloud Service Reliability Enhancement via Virtual Machine Placement Optimization, *IEEE Transactions on Services Computing (TSC)*, Volume 10, Number 6, Pages: 902-913, ISSN: 1939-1374, IEEE Computer Society Press, USA, November/December 2017.

Magazine Papers

46. Chii Chang, Satish Narayana Srirama, and Rajkumar Buyya, Indie Fog: An Efficient Fog-Computing Infrastructure for the Internet of Things, IEEE Computer, Volume 50, Issue 9, Pages: 40-46, ISSN: 0018-9162, IEEE CS Press, USA, September 2017.

Conference Papers

47. Alfredo Cuzzocrea, Rajkumar Buyya, Vincenzo Passanisi, and Giovanni Pilato, MapReduce-based Algorithms for Managing Big RDF Graphs: State-of-the-Art Analysis, Paradigms, and Future Directions, Proceedings of the 17th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid 2017, IEEE CS Press, USA), Madrid, Spain, May 14-17, 2017.
 48. Jaydeep Das, Arindam Dasgupta, Soumya K. Ghosh, and Rajkumar Buyya, A Learning Technique for VM Allocation to Resolve Geospatial Queries, Proceedings of the 5th International Conference on Advanced Computing, Networking, and Informatics (ICACNI 2017, Springer, Germany), Goa, India, June 1-3, 2017. - Best Paper Award in Computing.
 49. Imairi Eitiveni, Sherah Kurnia, and Rajkumar Buyya, Sustainable Supply Chain Management: Taxonomy, Gaps, and Future Directions, Proceedings of the 21st Pacific Asia Conference on Information Systems (PACIS 2017, AIS Press, Atlanta, USA), Langkawi, Malaysia, July 16-20, 2017.
 50. Xunyun Liu, Aaron Harwood, Shanika Karunasekera, Benjamin Rubinstein, and Rajkumar Buyya, E-Storm: Replication-based State Management in Distributed Stream Processing Systems, Proceedings of the 46th International Conference on Parallel Processing (ICPP 2017, IEEE CS Press, USA), Bristol, UK, August 14-17, 2017.
 51. Muhammad Hafizhuddin Hilman, Maria Alejandra Rodriguez, and Rajkumar Buyya, Task-based Budget Distribution Strategies for Scientific Workflows with Coarse-grained Billing Periods in IaaS Clouds, Proceedings of the 13th IEEE International Conference on e-Science (e-Science 2017, IEEE CS Press, USA), Auckland, New Zealand, October 24-27, 2017.
 52. Muhammed Tawfiqul Islam, Shanika Karunasekera, and Rajkumar Buyya, dSpark: Deadline-based Resource Allocation for Big Data Applications in Apache Spark, Proceedings of the 13th IEEE International Conference on e-Science (e-Science 2017, IEEE CS Press, USA), Auckland, New Zealand, October 24-27, 2017.
 53. Bowen Zhou and Rajkumar Buyya, A Group-based Fault Tolerant Mechanism for Heterogeneous Mobile Clouds, Proceedings of the 14th International Conference on Mobile and Ubiquitous Systems: Computing, Networking and Services (Mobiquitous 2017), Melbourne, Australia, November 7-10, 2017.
 54. Minxian Xu and Rajkumar Buyya, Energy Efficient Scheduling of Application Components via Brownout and Approximate Markov Decision Process, Proceedings of the 15th International Conference on Service-Oriented Computing (ICSOC 2017, LNCS, Springer-Verlag Press, Berlin, Germany), Málaga, Spain, November 13-16, 2017.
 55. Carlos Mera-Gomez, Francisco Ramírez, Rami Bahsoon, and Rajkumar Buyya, A Debt-Aware Learning Approach for Resource Adaptations in Cloud Elasticity Management, Proceedings of the 15th International Conference on Service-Oriented Computing (ICSOC 2017, LNCS, Springer-Verlag Press, Berlin, Germany), Málaga, Spain, November 13-16, 2017.
 56. Xunyun Liu and Rajkumar Buyya, D-Storm: Dynamic Resource-Efficient Scheduling of Stream Processing Applications, Proceedings of the 23rd IEEE International Conference on Parallel and Distributed Systems (ICPADS 2017, IEEE CS Press, USA), Shenzhen, China, December 15-17, 2017.
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57. Ehsan Nadjaran Toosi, Adel Nadjaran Toosi, Reza Godaz, and Rajkumar Buyya, Integrated IoT and Cloud Environment for Fingerprint Recognition, Proceedings of the International Conference on Fog Computing and Internet of Things (ICFCIoT 2017), Hyderabad, India, December 21-22, 2017.
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5. Invited Presentations and Outreach

By the Lab Director:

Keynote Talks at International Conferences

1. International Symposium on Big Data and Cloud Computing Challenges (ISBCC 2017), Chennai, India, March 9-10, 2017.
2. International Symposium on Cloud Computing and Data Analytics (ISCCDA 2017), Mysuru, India, March 17-18, 2017.
3. International Conference on Emerging Trends in Engineering, Science and Technologies (ICETEST 2017), Tirupati, India, March 18-20, 2017.
4. International Conference on Big Data Analytics and Computational Intelligence (ICBDACI 2017), Chirala, Andhra Pradesh, India, March 23-25, 2017.
5. International Workshop on Big Data and Information Security (IWBIS 2017), Jakarta, Indonesia, September 23-24, 2017.
6. 5th International Conference on Soft Computing, Intelligent System and Information Technology (ICSIIT 2017), Bali, Indonesia, September 26-29, 2017.
7. 3rd International Conference on Next Generation Computing Technologies (NGCT-2017), Dehradun, India, Oct. 30-31, 2017.
8. 2017 Conference on Information and Communication Technology (CICT-2017), Gwalior, India, November 3-5, 2017.
9. International Conference on Data Security (INCODE 2017), Krishnankoil, Tamil Nadu, India, December 11-13, 2017.
10. 9th International Conference on Advanced Computing (ICoAC 2017), Chennai, India, December 14-16, 2017.
11. International Conference on Computing Analytics and Networking (ICCAN 2017), Bhubaneswar, India, December 15-16, 2017.
12. 11th IEEE International Conference on Advanced Networks and Telecommunications Systems (ANTS 2017), Bhubaneswar, India, December 17-20, 2017.
13. International Conference on Fog Computing and Internet-of-Things (ICFCIoT 2017), Hyderabad, India, December 21-22, 2017.

National Conferences

1. A Melbourne View of Smart Cities: Innovations in IoT and Cloud Computing, City Disrupt Conference, Melbourne, Australia, February 22, 2017.
2. New Frontiers in Cloud Computing for Big Data and (IoT) Applications, International Workshop on Big Data and Machine Learning (IWBDML 2017), CBIT, Hyderabad, India, March 28, 2017.

Seminars - in Cloud Computing area:

1. New Frontiers in Cloud Computing for Big Data and IoT Applications, K L University, Vijayawada, India, March 24, 2017.
2. New Frontiers in Cloud Computing for Big Data and IoT Applications, Karnatak Arts, Science and Commerce College, Bidar, India, March 25, 2017.
3. New Frontiers in Cloud Computing for Big Data and Internet-of-Things (IoT) Applications, Distinguished Lecture, Hyderabad University, Hyderabad, India, March 27, 2017.
4. Green Cloud Computing, Institute for Development & Research in Banking Technology (IDRBT), Hyderabad, India, March 28, 2017.
5. New Frontiers in Cloud Computing for Big Data and IoT Applications, Universidad Complutense de Madrid (UCM), Madrid, Spain, May 16, 2017.

6. New Frontiers in Cloud Computing for Big Data and IoT Applications, University of Birmingham, Birmingham, United Kingdom (UK), May 18, 2017.
7. New Frontiers in Cloud Computing for Big Data and IoT Applications, Newcastle University, Newcastle upon Tyne, United Kingdom (UK), May 22, 2017.
8. New Frontiers in Cloud Computing for Big Data and IoT Applications, City, University of London, London, United Kingdom (UK), May 24, 2017.
9. New Frontiers in Cloud Computing for Big Data and IoT Applications, Imperial College London (ICL), London, United Kingdom (UK), May 25, 2017.
10. New Frontiers in Cloud Computing for Big Data and IoT Applications, University of Mauritius, Reduit, Mauritius, May 30, 2017.
11. Excellence and Impact of Research and Research Publications, University of Mauritius, Reduit, Mauritius, June 1, 2017.
12. New Frontiers in Cloud Computing for Big Data and IoT Applications, University of Technology Sydney (UTS), Sydney, Australia, August 2, 2017.
13. New Frontiers in Cloud Computing for Big Data and IoT Applications, Queensland University of Technology (QUT), Brisbane, Australia, August 3, 2017.
14. New Frontiers in Cloud Computing for Big Data and IoT Applications, Griffith University, Brisbane, Australia, August 4, 2017.
15. Excellence and Impact of Research and Research Publications, University of Indonesia, Jawa Barat, Indonesia, September 22, 2017.
16. Excellence and Impact of Research and Research Publications, University of Tasmania, Hobart, Australia, October 6, 2017.
17. Excellence and Impact of Research and Research Publications, Institute for Development & Research in Banking Technology (IDRBT), Reserve Bank of India (RBI), Hyderabad, India, October 25, 2017.
18. New Frontiers in Cloud Computing for Big Data and IoT Applications, G. Narayanamma Institute of Technology and Science (GNITS), Hyderabad, India, October 25, 2017.
19. Excellence and Impact of Research and Research Publications, University of Hyderabad, Hyderabad, India, October 27, 2017.
20. Excellence and Impact of Research and Research Publications, Jawaharlal Nehru University (JNU), Delhi, India, November 6, 2017.
21. A Melbourne View of Smart Cities: Innovations in IoT and Cloud Computing, Madhav Institute of Technology and Science (MITS), Gwalior, India, November 2, 2017.
22. New Frontiers in Cloud Computing for Big Data and IoT Applications, Singapore University of Social Sciences (SUSC), Singapore, November 8, 2017.
23. A Manifesto for Future Generation Cloud Computing: Research Directions for the Next Decade, Institute for Development and Research in Banking Technology (IDRBT), Hyderabad, India, December 20, 2017.
24. New Frontiers in Cloud Computing for Big Data and IoT Applications, Bheemanna Khandre Institute of Technology (BKIT), Bhalki, India, December 23, 2017.
25. A Manifesto for Future Generation Cloud Computing: Research Directions for the Next Decade, University of Hyderabad, Hyderabad, India, December 26, 2017.

6. Selected Community Services

By the Lab Director:

IEEE Computer Society

1. Advisory Board, IEEE Technical Committee on Scalable Computing
2. Coordinator (Australia and New Zealand), Technical Committee on Parallel Processing (TCPP)

Software: Practice and Experience (Wiley)

1. Co-Editor in Chief (EiC), 2014-to date.

Journal Editorials

1. Editorial Board Member, *International Journal of Parallel, Emergent and Distributed Systems* (IJPEDS), ISSN: 1744-5760, Taylor & Francis Group, UK.
2. Editorial Board Member, *Multiagent and Grid Systems: An International Journal*, ISSN: 1574-1702, IOS Press, Amsterdam, The Netherlands, 2005 onwards.
3. Associate Editor, *IEEE Internet of Things Journal*, IEEE, USA, 2013-2015.
4. Editorial Board Member, *International Journal of Parallel, Emergent and Distributed Systems* (IJPEDS), ISSN: 1744-5760, Taylor & Francis Group, UK, 2006-2013. IJPEDS), ISSN: 1744-5760, Taylor & Francis Group, UK, 2013-to date.
5. Editorial Board Member, *International Journal of Autonomous and Adaptive Communications Systems*, ISSN: 1754-8632, Inderscience Publishers, Geneva, Switzerland, 2007-to date.

Conference Steering Committee

1. Founder and Chair, IEEE/ACM International Symposium on Cluster, Cloud, and Grid Computing (CCGrid), 2001-to date.
2. Advisory Committee Member, International Conference on e-Science (e-Science), 2011-to date.
3. Advisory Committee Member, IEEE International Conference on Cluster Computing (ClusterXY), 2011-to date.
4. Member, International Symposium on Computer Architecture and High Performance Computing, Brazil, 2005-to date.
5. Founder and Chair, IEEE/ACM International Conference on Utility and Cloud Computing (UCC) series, 2009-to date.

Technical Program Committee Memberships

1. Track Chair, 27th IEEE International Conference on Computer Communications and Networks (ICCCN 2018) , July 30 -August 2, 2018, Hangzhou, China.
2. General Chair, IEEE International Conference on Fog and Edge Computing (ICFEC2017) (in conjunction with IEEE/ACM CCGrid, May 14-17, 2017), Madrid, Spain.
3. ACM SIGOPS Asia-Pacific Workshop on Systems (APSys 2017), September 2-3, 2017, Bombay, India.
4. 17th IEEE International Conference on Scalable Computing and Communications (ScalCom 2017), August 4-8, 2017, San Francisco, USA.
5. 17th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid 2017), May 14-17, 2017, Madrid, Spain.

6. 5th International Conference on Cloud Computing Research and Innovation (ICCCRI 2017), April 11-12, 2017, Singapore.

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 amongst top #4 sources for grid computing by Google search engine.
- Maintained a Cluster Computing Information Centre at: <http://www.buyya.com/cluster>

By Other Members:

Technical Program Committee Memberships

NIL

7. Members Profile and Activities

Member Self Profile: Adel Nadjaran Toosi

I am a Research Fellow at CLOUDS. In 2017, I have been working on algorithms and software systems for resource management of software-defined clouds. As part of this project, with help of Jay, I made a testbed for conducting practical experiments in software-defined clouds called "CLOUDS-Pi". The exiting part of this setup is that we used Raspberry-Pi's to build OpenFlow switches.

In 2017, I have submitted two successful funding proposals as follows:

1. Rajkumar Buyya, Adel Nadjaran Toosi, and Maria Rodriguez Sossa, "*Cost-Efficient Orchestration of Containers in Clouds*", Global Research Outreach (GRO) Program, Samsung, South Korea, Oct. 2017-2018. Amount: US\$120,000 (~A\$150,000).
2. Adel Nadjaran Toosi, Chief Investigator, "*RenewMan: Managing Renewable Energy in Sustainable Cloud Data Centres*", The University of Melbourne 2018 Early Career Researcher Grants Scheme, Amount: \$32,302.

Some of my co-authored papers (earlier or in 2017) have appeared/appearing as follows:

1. Adel Nadjaran Toosi, Richard O. Sinnott, and Rajkumar Buyya, Resource provisioning for data-intensive applications with deadline constraints on hybrid clouds using Aneka, *Future Generation Computer Systems (FGCS)*, Vol. 79, no. part 2, pp. 765-775, Elsevier, 2018.
2. Mohammad Sadegh Aslanpour, Mostafa Ghobaei Arani, and Adel Nadjaran Toosi, Auto-scaling Web Applications in Clouds: A Cost-Aware Approach, *Journal of Network and Computer Applications (JNCA)*, Vol. 95, pp. 26-41, Oct. 2017.
3. Atefeh Khosravi, Adel Nadjaran Toosi, and Rajkumar Buyya, Online Virtual Machine Migration for Renewable Energy Usage Maximization in Geographically Distributed Cloud Data Centers, *Concurrency and Computation: Practice and Experience (CCPE)*, Vol. 29, no. 18, Wiley, Sept. 2017.
4. Adel Nadjaran Toosi, Chenhao Qu, Marcos Dias de Assuncao, and Rajkumar Buyya, Renewable-aware Geographical Load Balancing of Web Applications for Sustainable Data Centers, *Journal of Network and Computer Applications (JNCA)*, Vol. 83, pp. 155-168, Elsevier, Apr. 2017.
5. Yaser Mansouri, Adel Nadjaran Toosi, and Rajkumar Buyya, Cost Optimization for Dynamic Replication and Migration of Data in Cloud Data Centers, *IEEE Transactions on Cloud Computing (TCC)*, IEEE, doi:10.1109/TCC.2017.2659728, 2017 (in press, available online 26 January 2017).



My CV and full list of my publications can be found in my homepage at <http://adelnadjarantoosi.info/>

Member Self Profile: Maria Alejandra Rodríguez

I joined the CLOUDS Laboratory in 2012 as a student researching scheduling and resource provisioning algorithms for scientific workflows in cloud environments. I completed my PhD in 2016 and I am now working as a research fellow in the lab.

I have researched different topics as part of my current role. I have investigated multi-tenant workflow-as-a-service frameworks and have proposed an adaptive scheduling and resource management algorithm that uses containers as a cost- and energy-reducing mechanism. I have also investigated the use of anomaly detection techniques to mitigate the effects of performance variation and failures in the execution of extreme scale scientific workflows in cloud computing environments. Currently I am researching container orchestration frameworks and different ways in which the use of resources can be optimized in container-based environments.

I have a bachelor's degree in Computing and Systems Engineering from Los Andes University in Colombia. In 2011 I completed my master's degree at the University of Melbourne (Master of Engineering in Distributed Computing) with first class honors. I have over three years of industry experience gained while working as a software engineer in Colombia and in Tata Consultancy Services in Bangalore, India.



Some of my papers published in 2017 are:

Maria A. Rodriguez and Rajkumar Buyya, [Scientific Workflow Management System for Clouds, Software Architecture for Big Data and the Cloud](#), I. Mistrik, R. Bahsoon, N. Ali, M. Heisel, and B. Maxim (eds), 357-387pp, ISBN: 9780128054673, Morgan Kaufmann, Burlington, Massachusetts, USA, June 2017.

Maria A. Rodriguez and Rajkumar Buyya, [A Taxonomy and Survey on Scheduling Algorithms for Scientific Workflows in IaaS Cloud Computing Environments](#), Concurrency and Computation: Practice and Experience (CCPE), Volume 29, No. 8, Pages: 1-23, ISSN: 1532-0626, Wiley Press, New York, USA, April 25, 2017.

Maria A. Rodriguez and Rajkumar Buyya, [Budget-Driven Scheduling of Scientific Workflows in IaaS Clouds with Fine-Grained Billing Periods](#), ACM Transactions on Autonomous and Adaptive Systems (TAAS), Volume 12, Number 2, Article No.: 5, Pages: 1-22, ISSN:1556-4665, ACM Press, New York, USA, May 2017.

Member Self Profile: Sukhpal Singh Gill

I am currently a post-doctorate research fellow at CLOUDS Lab and my research interests include quality of service-based resource management in clouds. Currently, I am focusing on practical aspects of cloud computing by learning tools such as CloudSim and Aneka.

During 2017, I have been serving as a peer reviewer for IEEE Transactions on Service computing, IEEE Transactions on Big Data, IEEE Transactions on Sustainable Computing, Software: Practice and Experience, Computational Intelligence, Future Generation Computer Systems, International Journal of Automation and Computing, Enterprise Information Systems, International Journal of High Performance Computing and Networking and Journal of Grid Computing.

I have a Doctorate's degree in QoS-aware autonomic resource provisioning and scheduling for Cloud computing. I designed an intelligent cloud based and QoS-aware autonomic resource management approach which offers self-configuration of applications and resources, self-healing by handling sudden failures, self-protection against security attacks and self-optimization for maximum resource utilization.



Below you can find my selected publications related to my research in 2017:

1. **Sukhpal Singh Gill**, Rajkumar Buyya, Inderveer Chana, Maninder Singh and Ajith Abraham, "BULLET: Particle Swarm Optimization based Scheduling Technique for Provisioned Cloud Resources", *Journal of Network and Systems Management*, Springer, 2017 (in press, accepted on July 25, 2017)
2. **Sukhpal Singh Gill**, Inderveer Chana, Maninder Singh and Rajkumar Buyya, "CHOPPER: An Intelligent QoS-aware Autonomic Resource Management Approach for Cloud Computing", *Cluster Computing*, Springer, 2017 (in press, accepted on July 10, 2017)
3. **Sukhpal Singh Gill**, Inderveer Chana and Rajkumar Buyya, "IoT based Agriculture as a Cloud and Big Data Service: The Beginning of Digital India", *Journal of Organizational and End User Computing (JOEUC)*, IGI Global, vol. 29, no. 4, pp. 1-23, 2017
4. **Sukhpal Singh**, Inderveer Chana and Rajkumar Buyya, "STAR: SLA-aware Autonomic Management of Cloud Resources," *Transactions on Cloud Computing*, IEEE, 2017, (in press, accepted on January 12, 2017)

My CV and full list of my publications can be found in my cyber homepage at: <http://ssgill.in/>

Member Self Profile: Jungmin Son (Jay)

I started PhD study with CLOUDS Lab since 2014, following a master project conducted under the supervision of Prof Buyya and Dr Calheiros in 2013. I completed Master of Information Technology from the University of Melbourne and Bachelor of Engineering in Information and Computer Engineering from Ajou University, South Korea. I worked in Samsung Electronics as a software engineer for four years where I was in charge of research and development of multimedia software for various Samsung mobile phones.

My current research interests include mythologies of applying SDN technology in cloud computing context, for SLA, QoS, and energy efficiency. In 2017, as a final-year PhD candidate, I studied for QoS-aware resource allocation method in SDN-Clouds and developed an integrated control system to manage both Compute and Network resources in Clouds simultaneously.



For further information, please visit:

- Homepage: <https://sites.google.com/site/jungminjayson/>
- Github: <https://github.com/fogony/cloudsimsdn>
- LinkedIn: <http://au.linkedin.com/pub/jungmin-jay-son/4b/369/bab/>

Member Self Profile: Bowen Zhou

My name is Bowen Zhou and I am from Harbin, China. I joined CLOUDS Lab in the Department of Computing and Information System in University of Melbourne in February 2014 under the supervision of Prof. Rajkumar Buyya and the external supervisor Prof. Satish Narayana Srirama from the University of Tartu.

I received my Bachelor degree on information security in Harbin Institute of Technology in 2013. I had an internship in network security lab in HIT during the last year to develop pattern recognition algorithms for network traffic. My PhD research is on Mobile cloud computing. The work is related to developing framework and offloading policies for mobile code offloading.

My recent publications include:

1. B. Zhou, and R. Buyya, A Group-based Fault Tolerant Mechanism for Heterogeneous Mobile Clouds, in Proceedings of the 14th EAI International Conference on Mobile and Ubiquitous Systems: Computing, Networking and Services (Mobiquitous 2017), Melbourne, Australia, 7-10 Nov, 2017
2. B. Zhou; A. Vahid Dastjerdi; R. Calheiros; R. Buyya, "[An Online Algorithm for Task Offloading in Heterogeneous Mobile Clouds](#)" in ACM Transactions on Internet Technology, Volume 18, Issue 2, Article NO.23
3. B. Zhou; R. Buyya, "[Augmentation Techniques for Mobile Cloud Computing: A Taxonomy, Survey, and Future Directions](#)" in ACM Computing Surveys, Volume 51, Issue 1, Article No.13



For more information, please visit:

Linkedin: <https://www.linkedin.com/in/bowenzhou/>

Personal website: <http://www.bowenzhou.com/>

Member Self Profile: Safiollah Heidari

I joined CLOUDS Lab in Jun 2014 at the University of Melbourne as a PhD student under the supervision of Prof. Rajkumar Buyya, Dr. Benjamin Rubinstein and Dr. Rodrigo N. Calheiros.

Previously I have graduated from K. N. Toosi University of Technology, Tehran, Iran, with First Class Honors degree in M.Sc. in Information Technology and I have published a number of papers during my studies. I am also member of Iran's National Elites Foundation, a prestigious organization for recognize, organize and support Iran's elite national talents. I have more than three years of experiences working as a software engineer in different companies in Iran and also as a university lecturer.



At CLOUDS Lab, I'm investigating resource provisioning, cost saving, workflow scheduling and network aspects of large-scale graph-processing systems, Big Data and social networks on cloud environments. I have developed iGiraph which is a novel Pregel-like graph processing framework for minimizing the monetary costs and computation time of processing on large-scale graph datasets. iGiraph's paper was appeared in CCGrid 2016 conference in Colombia and also won the Google Ph.D. travel prize at University of Melbourne and the runner-up prize for the best student paper from IEEE Victorian Section.

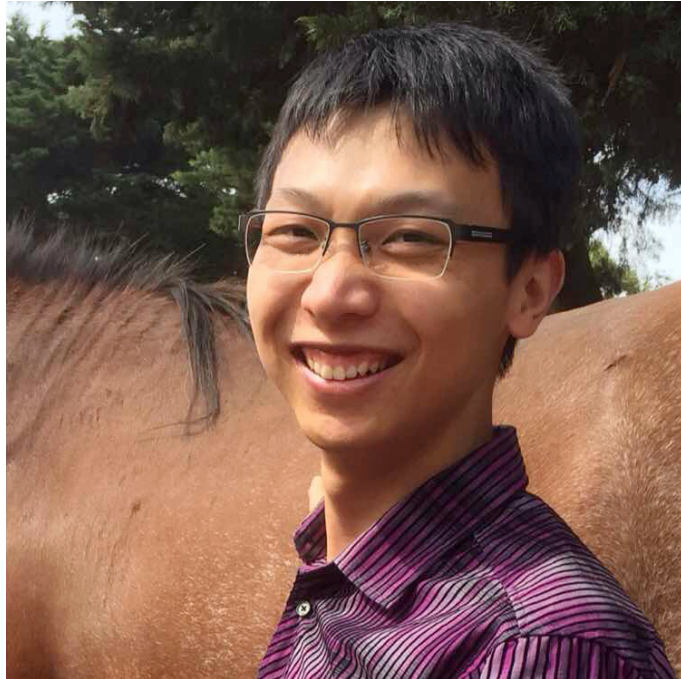
With further improvements in 2017, iGiraph is now considering important network factors such as bandwidth, traffic, computation capacity, latency, etc. to enhance the system performance. It is also equipped by a new heterogeneity-aware resource provisioning mechanism which decreases the costs of processing large-scale graphs even more in public clouds. Meanwhile, I wrote a taxonomy on graph processing systems that comprehensively investigates different aspects of these emerging solutions and is submitted to ACM Computing Survey.

Recently, we have introduced "Graph Processing-as-a-Service" (GPaaS) as the next popular cloud service where a full-stack of services is proposed for cloud providers by which GPaaS will play a key role in data storage and analytics within organizations.

Member Self Profile: Xunyun Liu

I joined the Clouds lab at University of Melbourne in Sept. 2014, under the supervision of Professor Rajkumar Buyya and Dr. Rodrigo N. Calheiros. In 2015, Dr. Benjamin Rubinstein joined my supervisory committee and I was confirmed as a formal PhD candidate.

I graduated from National University of Defense Technology with a master and a bachelor degree on Computer Science and Technology. My research at that time mainly focused on High Performance Computing (HPC) and compiler optimization. In my Master thesis, I designed a fault-tolerant, sender-based message logging protocol over MPI for fast recovery of faulty scientific applications on the world-renowned TH supercomputer.



After the focus of my PhD shifts to the research of Cloud computing, I started developing interested in stream processing of big data on cloud, including resource provisioning, task scheduling, and fault tolerance issues related to real-time processing. Using Apache Storm as the experiment platform, I have been actively working towards the design and implementation of a SLA-oriented streaming processing platform on cloud.

You are welcome to visit my personal page at <https://xunyunliu.github.io/> for the list of my publications and my thoughts in the field of stream processing.

Member Self Profile: Caesar Wu



I was one of the telecommunication veterans. I worked for Telstra Corporation over 18 years. Before I joined Telstra, I had worked for many companies across different industries, such as software (artificial intelligence research), naval architecture, electronics, telecommunication, civil engineering, and space industry. In 2015, I started up my Ph.D. research journey under the supervision of prestige Professors: Ramamohanarao Kotagiri and Rajkumar Buyya in Computing and Information Systems (CIS) /School of Engineering/The University of Melbourne.

My research interests include cloud pricing modeling, cloud market segmentation, cloud data center analysis, IT vendor management, cloud resource and capacity planning, data mining, machine learning algorithms, artificial intelligence, IT solution architecture, IT service delivery, and project management.

In Mar 2015, Prof Raj and I completed the book of Cloud Data Center Cost Modeling based on years' experiences across different types of Telstra data centers (Cloud data centers, Next Generation multimedia data centers, enterprise business hosting data centers, and IT data centers).

<http://www.amazon.com.au/Cloud-Data-Centers-Cost-Modeling-ebook/dp/B00UJBCSA0>

In 2016, we wrote a book chapter: Big Data Analytics = Machine Learning + Cloud Computing."

In 2017, we also wrote two papers of "Hedonic Pricing of Cloud Computing Services" and "Cloud Pricing Models: Taxonomy, Survey, and Interdisciplinary Challenges."

Member Self Profile: Minxian Xu

I joined CLOUDS lab in October 2015, pursuing my PhD position under the supervision of Prof. Rajkumar Buyya at University of Melbourne.

Before coming to Melbourne, I obtained both my bachelor and master degrees at University of Electronic Science and Technology of China (UESTC), both majoring in Software Engineering. During my graduate time, my research mainly focused on resource scheduling and load balancing in Cloud data centers.

During my PhD candidature, I'm still working on resource scheduling, especially investigating energy efficient scheduling for Clouds. I have co-authored several papers by now. If you have interest, please find them below:

1. **Minxian Xu**, Rajkumar Buyya, *BrownoutCon: A Software System based on Brownout and Containers for Energy Efficient Clouds*, under review of IEEE Transactions on Automation Science and Engineering (under review)
2. **Minxian Xu**, Adel Nadjaran Toosi, Rajkumar Buyya, *iBrownout: An Integrated Approach for Managing Energy and Brownout in Container-based Clouds*, IEEE Transactions on Sustainable Computing, special issue on "Smart Data and Deep Learning Computing (SDDL)" (under second round review)
3. **Minxian Xu**, Rajkumar Buyya, *Energy Efficient Scheduling of Application Components via Brownout and Approximate Markov Decision Process*, In the Proceedings of International Conference on Service Oriented Computing (ICSOC), pp.206-220, Nov 2017.
4. **Minxian Xu**, Wenhong Tian, Rajkumar Buyya, *A Survey on Load Balancing Algorithms for Virtual Machines Placement in Cloud Computing*, Concurrency and Computation: Practice and Experience, Vol 29, Issue 12, June 2017.
5. **Minxian Xu**, Amir Vahid Dastjerdi, Rajkumar Buyya, *Energy Efficient Scheduling of Cloud Application Components with Brownout*, IEEE Transactions on Sustainable Computing, vol. 1, issue 2, pp.40-53, Dec 2016.



For more information, please visit my personal site:
<https://sites.google.com/site/minxianxuhome/>

Member Self Profile: Sara Kardani Moghaddam

I joined CLOUDS Lab as a PhD student in September 2015, under the supervision of Professor Ramamohanarao Kotagiri and Professor Rajkumar Buyya in the University of Melbourne.

Prior to joining the CLOUDS Lab Group, I received my Bachelor's degree with First Class Honors from Shiraz University of Technology and after that I completed a master degree in Information Technology at Sharif University of Technology. Before starting my PhD studies, I also worked for 3 years as a Software Designer and Developer in Iran.

My research interests include data analytics, anomaly detection, Cloud performance management and optimization techniques.

Currently, I'm investigating the concepts of Big Data analytics and how we can exploit these capabilities to find better ways of resource provisioning and auto-scaling in Cloud computing environment.



Member Self Profile: Md. Redowan Mahmud

I completed my BSc from *Department of Computer Science and Engineering, University of Dhaka, Bangladesh* in 2015. Later I was appointed as a lecturer in *Department of Computer Science and Engineering, United International University, Bangladesh*.

I have joined *Cloud Computing and Distributed Systems (CLOUDS) Laboratory, Department of Computing and Information Systems, University of Melbourne, Australia* in February, 2016. Here, I have been awarded with Melbourne International Research Scholarship (MIRS) and Melbourne International Fee Remission Scholarship (MIFRS) for supporting my studies.



Now, I am in third year of my PhD candidature and exploring resource management and application placement in Fog computing environment. Till date, I have authored 1 book chapter, 2 conference paper and 2 journal papers on Fog computing.

To follow my research activities, please visit https://www.researchgate.net/profile/Md_Mahmud14 and <https://scholar.google.com.au/citations?user=rliTpSsAAAAJ&hl=en>

Member Self Profile: Muhammed Tawfiqul Islam

I have joined CLOUDS lab on July, 2016 as a PhD student. I am also a Lecturer at the Department of Computer Science & Engineering, University of Dhaka, Bangladesh and currently I am on a study leave. My research focus in PhD is on “SLA-based cloud resource management for Big Data Applications”.

Prior to finishing my BSc. and MS studies, I have worked as a software engineer in REVE systems, where I developed VOIP servers in H.323 and SIP protocols. In my MS research, I worked in collaboration with Internet Society (ISOC) to fight for the cause “Net Neutrality”. I developed end-user applications to detect any blocking/shaping to Internet bandwidth/ services by their Internet Service Providers (ISP) and this project was funded by ISOC Netherlands.



Currently, I am working on developing efficient resource scheduling algorithms for big data applications. In the year 2017, I have published 1 conference paper in IEEE 13th International Conference on e-Science. If you are interested, find it below:

- M. T. Islam, S. Karunasekera and R. Buyya, "dSpark: Deadline-Based Resource Allocation for Big Data Applications in Apache Spark," *2017 IEEE 13th International Conference on e-Science (e-Science)*, Auckland, New Zealand 2017, pp.89-98. doi: 10.1109/eScience.2017.21

Member Self Profile: Muhammad Hafizhuddin Hilman



I joined CLOUDS Lab as a PhD student in January 2016 under the supervision of Prof. Rajkumar Buyya and Dr Amir Vahid Dastjerdi. I am working on Scientific Workflow Management under direct supervision from Research Fellow, Dr Maria A. Rodriguez. My area of interest includes Cloud Computing, Scientific Workflows, Cloud Scheduling and Cloud Resource Management.

As part of my PhD research, I investigate into the workflow-as-a-service environment. Directly, putting scientific workflow computation into service that provides utility leasing for the scientific users. I work on several algorithms on dynamic scheduling and resource provisioning for multiple workflows and modelling the workflow-as-a-service environment. I have presented one of my work at The 13th International Conference on e-Science (e-Science) 2017 at Auckland, New Zealand titled “Task-based Budget Distribution Strategies for Scientific Workflows with Coarse-grained Billing Periods in IaaS Clouds”.

I am currently staff-on-leave from Faculty of Computer Science, Universitas Indonesia. I got the scholarship from Indonesian Government to pursue PhD at the University of Melbourne. I got my bachelor and master degree from Universitas Indonesia at 2010 and 2012.

For further information, please refer to my LinkedIn page

<https://www.linkedin.com/in/muhammadhilman/>

Member Self Profile: Shashikant Ilager

I joined CLOUDS Lab as a PhD student in March 2017 under the supervision of Prof. Rajkumar Buyya and Prof. Rao Kotagiri. My PhD studies are supported by Melbourne Research Scholarship (MRS). Before moving to Melbourne, I received my Master of Technology (M.Tech) in Computer Science from the University of Hyderabad, India in 2016 and Bachelor of Engineering (B.E) from VTU, Karnataka, India in 2013.

My research interest lies in Distributed Systems and Cloud Computing. As part of my PhD thesis, I am investigating different resource provisioning and scheduling techniques to optimize the energy consumption of cooling and computing systems of cloud datacenter.

For more information, kindly visit the following links.

Website: <http://www.shashikantilager.com>

LinkedIn: <https://www.linkedin.com/in/shashikantilager/>



Member Self Profile: Tianzhang He

I joined CLOUDS lab in Aug 2017, pursuing my PhD position under the supervision of Prof. Rajkumar Buyya and Dr. Adel Nadjaran Toosi at University of Melbourne.

Before came to Melbourne, I obtained both my bachelor in 2014 in Computer Science and master degree in Computer System in 2017 at Northeastern University (NEU), China. During my graduate time, my research mainly focused on priority-based task scheduling algorithm and response time analysis in real-time systems. In my Master thesis, I analyse response time of OpenMP-based real-time tasks on multi-core systems and design a Benchmark tool called ompTG to transform OpenMP programs to the defined OpenMP-based DAG task model.



In the first 6 months of my PhD research, after transferring to the research on cloud computing, I'm working on resource scheduling through live migration in SDN-enabled cloud computing.

Member Self Profile: Satish Narayana Srirama



I am a Research Professor and the head of the Mobile & Cloud Lab at the Institute of Computer Science, University of Tartu, Estonia. My research focuses on cloud computing, mobile web services, mobile cloud, Internet of Things, fog computing, migrating scientific computing and enterprise applications to the cloud and large scale data analytics on the cloud. During April - August 2017, I have visited CLOUDS Lab as part of my sabbatical. During the visit, we have mainly collaborated in mobile cloud and fog computing domains. We have also co-ordinated in defining the manifesto for future generation cloud computing with the research focus at next decade.

Some of the joint publications are mentioned here:

- R. Mahmud, S. N. Srirama, R. Kotagiri, R. Buyya: Quality of Experience (QoE)-aware Placement of Applications in Fog Computing Environments, Journal of Parallel and Distributed Computing, ISSN: 0743-7315, 2018. Elsevier. (In Print)
- C. Chang, S. N. Srirama, R. Buyya: Indie Fog: An Efficient Fog-Computing Infrastructure for the Internet of Things, IEEE Computer, ISSN: 0018-9162, 50(9):92-98, 2017. IEEE. DOI: 10.1109/MC.2017.3571049
- B. Zhou, A. V. Dastjerdi, R. N. Calheiros, S. N. Srirama, R. Buyya: mCloud: A Context-aware Offloading Framework for Heterogeneous Mobile Cloud, IEEE Transactions on Services Computing, ISSN: 1939-1374, 10(5):797-810, 2017. IEEE. DOI: 10.1109/TSC.2015.2511002
- Rajkumar Buyya, Satish Narayana Srirama, Giuliano Casale, Rodrigo Calheiros, Yogesh Simmhan, Blessen Varghese, Erol Gelenbe, Bahman Javadi, Luis Miguel Vaquero, Marco A. S. Netto, Adel Nadjaran Toosi, Maria Alejandra Rodriguez, Ignacio M. Llorente, Sabrina De Capitani di Vimercati, Pierangela Samarati, Dejan Milojicic, Carlos Varela, Rami Bahsoon, Marcos Dias de Assuncao, Omer Rana, Wanlei Zhou, Hai Jin, Wolfgang Gentzsch, Albert Zomaya, and Haiying Shen: A Manifesto for Future Generation Cloud Computing: Research Directions for the Next Decade, ACM Computing Surveys (Under Review).

Member Self Profile: Marcos Dias de Assuncao

I am a researcher at the French Institute for Research in Computer Science and Automation (Inria), LIP, ENS Lyon, France. In 2017, I visited CLOUDS twice in the scope of a joint research project between CNRS and The University of Melbourne. I have been collaborating with colleagues from Melbourne University on topics related to resource management for data stream processing applications. Joint publications include:



Adel Nadjaran Toosi, Chenhao Qu, Marcos Dias de Assuncao, and Rajkumar Buyya, Renewable-aware Geographical Load Balancing of Web Applications for Sustainable Data Centers, Journal of Network and Computer Applications (JNCA), Vol. 83, pp. 155-168, Elsevier, Apr. 2017.

Marcos Dias de Assuncao, Alexandre Da Silva Veith, and Rajkumar Buyya, [Distributed Data Stream Processing and Edge Computing: A Survey on Resource Elasticity and Future Directions](#), Journal of Network and Computer Applications (JNCA), Volume 103, Pages: 1-17, ISSN: 1084-8045, Elsevier, Amsterdam, The Netherlands, February 1, 2018.

Member Self Profile: Arash Shaghaghi

I joined CLOUDS Lab as a Research Visitor working under the supervision of Distinguished Professor Rajkumar Buyya between August 2017 until December 2017. My visit was funded by CLOUDS Lab and my research focus during this time was the security of Software Defined Clouds (SDC) and Software-Defined Networks (SDN).

At my home institution, I am about to complete my Doctor of Philosophy in Computer Science at UNSW Sydney, where I am also affiliated with Data61, CSIRO as a research student. My PhD Research is shaped around the security of Software-Defined Networks and access control systems. My supervisors are Prof. Sanjay Jha and Prof. Mohamed Ali (Dali) Kaafar and I also work closely with A/Prof. Salil Kanhere. My PhD study is funded by Australian Government Research Training Program (RTP) Scholarship and The Data61 Top-up Scholarship.



Prior to joining UNSW Sydney, I completed an MSc in Information Security at University College London (UCL) and a double degree in BSc Information Technology and Software Engineering at Heriot-Watt University of Scotland.

My cyber-home is: Arash.Sydney

Member Self Profile: Ehsan Nadjaran Toosi

I received my M.Sc. in Computer Science and B.Sc. in Software Engineering from the University of Saarland, Germany in late 2017 and the Azad University of Mashhad in 2012 respectively.

I worked as a research assistant in Max Plank Institute for Informatics (MPI) in the department of Database and Information System from Jan. 2016 to Jul. 2017. My major task was developing and improving a new efficient algorithm for Boolean Matrix Factorization in the field of data mining. Later on, I submitted my M.Sc. thesis on the same topic there. From Oct. 2014 to Dec. 2015, I worked as a research assistant in German Research Center for Artificial intelligence (DFKI) in the department of Intelligent User Interface (IUI). I have been working in this department since Sept. 2017. As a member of a developing team, we developed an automobile driver's assistant which won the CES 2018 innovation award in Vehicle Intelligence and Self-Driving Technology category.

Our 3-member university programming team took a place among top 10 best programming university team in the whole country (Iran) during ACM International Collegiate Programming Contest in 2011. In 2015, as part of another programming team, I qualified for the final worldwide round of Google Hashcode programming contest.

In Nov 2017, I was honored to visit Clouds Lab within the School of Computing and Information Systems at the Melbourne University as a research visitor. My visit was supervised and fully funded by Prof. Buyya. During my research visit, we submitted a paper named, Integrated IoT and Cloud Environment for Fingerprint Recognition to International Conference on IoT and Fog Computing 2017. In this paper, we proposed a system for large-scale fingerprint matching application using Aneka.

For more information, please visit my Linkedin webpage: www.linkedin.com/in/ehsan-nadjaran-toosi



8. 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:

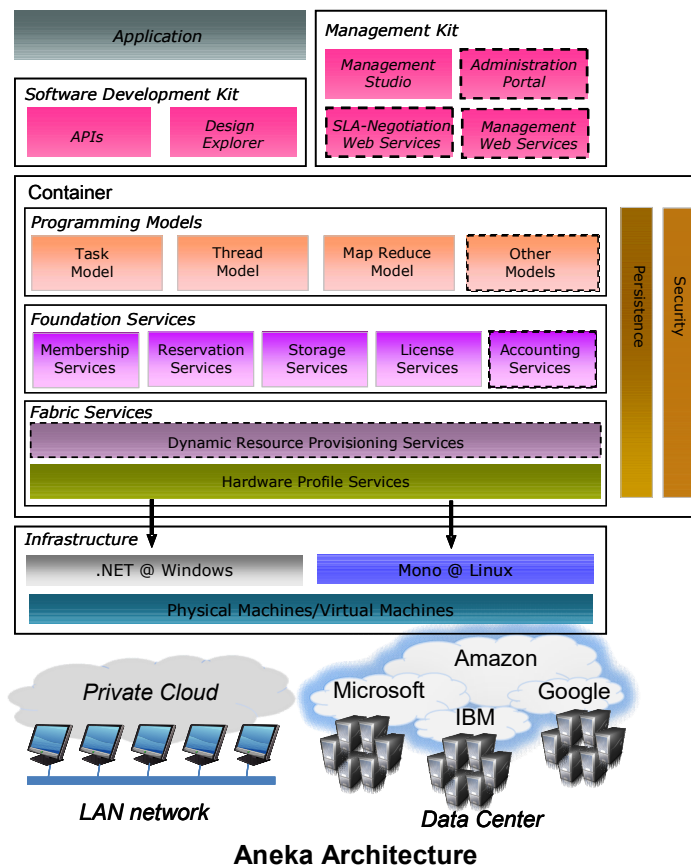
- Market Oriented Cloud Architecture
- Enterprise Cloud Application Platform (Aneka)
- Cloud Service Broker
- Cloud Workflows and Scheduling
- Service Level Agreements & Resource Allocation Systems (Libra).
- Energy-Efficient Data Centers and Clouds
- Cloud Simulation Toolkit (CloudSim).
- Application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

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.
- Cloudbrusting of application tasks across multiple Clouds (e.g., Azure and AWS)



QoS-Oriented Cloud Workflow Engine

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

Infrastructure-as-a-Service (IaaS) clouds offer several advantages for the deployment of scientific workflows. They enable Workflow Management Systems (WMSs) to access a flexible and scalable infrastructure by leasing Virtual Machines (VMs). This allows workflows to be easily packaged and deployed and more importantly, enables WMSs to access a virtually infinite pool of VMs that can be elastically acquired and released and are charged on a pay-per-use basis. In this way, cloud resources can be used opportunistically based on the number and type of tasks that need to be processed at a given point in time. This is a convenient feature as it is common for the task parallelism of scientific workflows to significantly change throughout their execution. The resource pool can be scaled out and in to adjust the number of resources as the execution of the workflow progresses. This facilitates the fulfilment of the quality-of-service (QoS) requirements by allowing WMSs to fine-tune performance while ensuring the available resources are efficiently used.

In this project we extend the Cloudbus WMS as a PaaS (Platform-as-a-Service) to support the cloud-computing paradigm. Specifically, the project aims to:

- Define an architectural framework and principles for the development of QoS-based workflow management in cloud environments,
- Develop QoS-based algorithms for scheduling scientific workflow applications,
- Develop policies and resource management algorithms tailored for the cloud resource model,
- Implement a prototype system by incorporating the algorithms and policies developed above, and
- Develop real world demonstrators in various scientific domains such as astronomy.

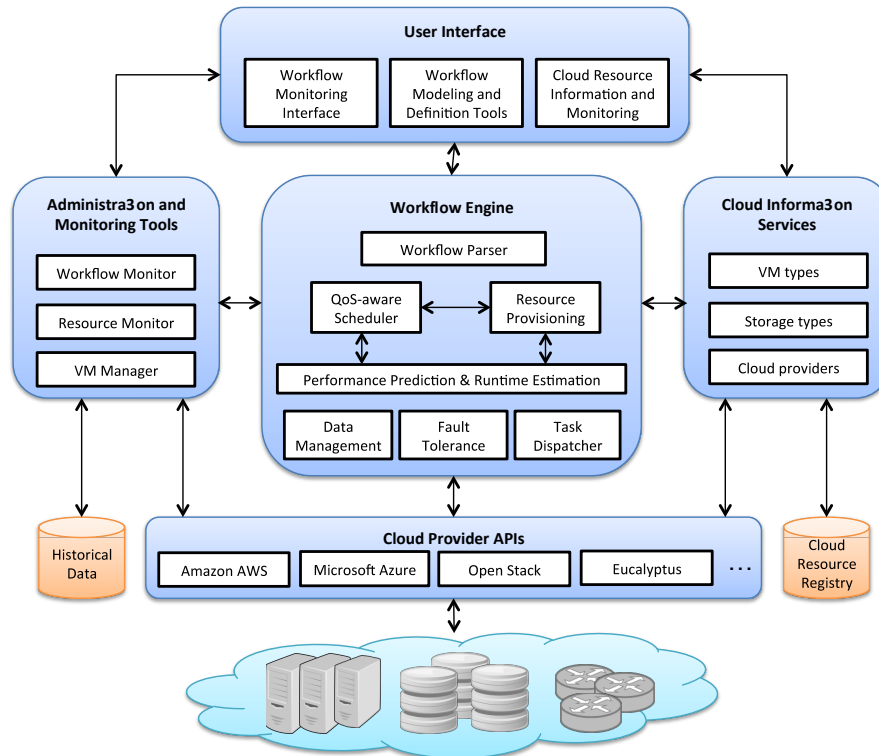


Fig. 1: Architecture of QoS-based workflow management and resource allocation system.

Some References:

- Maria A. Rodriguez and Rajkumar Buyya, Scientific Workflow Management System for Clouds, Software Architecture for Big Data and the Cloud, I. Mistrik, R. Bahsoon, N. Ali, M. Heisel, and B. Maxim (eds), 357-387pp, ISBN: 9780128054673, Morgan Kaufmann, Burlington, Massachusetts, USA, June 2017.
- Maria A. Rodriguez and Rajkumar Buyya, Budget-Driven Scheduling of Scientific Workflows in IaaS Clouds with Fine-Grained Billing Periods, ACM Transactions on Autonomous and Adaptive Systems (TAAS), Volume 12, Number 2, Article No.: 5, Pages: 1-22, ISSN:1556-4665, ACM Press, New York, USA, May 2017.
- Maria A. Rodriguez and Rajkumar Buyya, Deadline based Resource Provisioning and Scheduling Algorithm for Scientific Workflows on Clouds, IEEE Transactions on Cloud Computing, Volume 2, Number 2, Pages: 222-235, ISSN: 2168-7161, IEEE Computer Society Press, USA, April-June 2014.
- Suraj Pandey, Letizia Sammut, Rodrigo N. Calheiros, Andrew Melatos, and Rajkumar Buyya, Scalable Deployment of a LIGO Physics Application on Public Clouds: Workflow Engine and Resource Provisioning Techniques, Cloud Computing for Data-Intensive Applications, 3-25pp, Li, Xiaolin, Qiu, Judy (Eds.), ISBN: 978-1-4939-1904-8, Springer, Berlin, Germany, 2014.

The Green Cloud Project: Innovative Solutions for Energy-Efficient Cloud Computing

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

Traditionally, high-performance computing (HPC) community has focused on performance (speed). Since early 2000, several companies have started building Data Centers inspired by commodity HPC (cluster computing) systems-architecture for hosting/powering industrial applications including search engines such as Google. At the same time microprocessor vendors have not only doubled the number of transistors (and speed) every 18-24 months, but they have also doubled the power densities. That is, the tremendous increase in computer performance has come with an even greater increase in power usage. As a result operational cost of HPC systems including industrial Data Centre is rapidly growing. This is reflected from a statement by CEO of Google (Eric Schmit): "what matter most to Google is not speed but power, because data centers can consume as much electricity as a city."

The aim of Green Cloud Project is to develop high-end computing systems such as Clusters, Data Centers, and Clouds that allocate resources to applications hosting Internet services (e-Services) to meet not only users' quality of service requirements, but also minimise consumption of electric power. That is to, to improve power management and consumption by dynamically managing and configuring power-aware ability of system devices, such as processors, disks, and communication links.

Selected Publications:

- Anton Beloglazov and Rajkumar Buyya, Managing Overloaded Hosts for Dynamic Consolidation of Virtual Machines in Cloud Data Centers Under Quality of Service Constraints, IEEE Transactions on Parallel and Distributed Systems (TPDS), Volume 24, No. 7, Pages: 1366-1379, IEEE CS Press, Los Alamitos, CA, USA, July 2013.
- Atefeh Khosravi, Saurabh Kumar Garg, and Rajkumar Buyya, Energy and Carbon-Efficient Placement of Virtual Machines in Distributed Cloud Data Centers, Proceedings of the 19th International European Conference on Parallel and Distributed Computing (Euro-Par 2013, Springer, Berlin, Germany), Aachen, Germany, August 26-30, 2013.
- Anton Beloglazov and Rajkumar Buyya, OpenStack Neat: A Framework for Dynamic and Energy-Efficient Consolidation of Virtual Machines in OpenStack Clouds, Concurrency and Computation: Practice and Experience (CCPE), Volume 27, No. 5, Pages: 1310-1333, ISSN: 1532-0626, Wiley Press, New York, USA, April 2015.
- Sareh Fotuhi Piraghaj, Rodrigo N. Calheiros, Jeffrey Chan, Amir Vahid Dastjerdi, and Rajkumar Buyya, Virtual Machine Customization and Task Mapping Architecture for Efficient Allocation of Cloud Data Center Resources, The Computer Journal, Volume 59, No. 2, Pages: 208-224, ISSN 0010-4620, Oxford University Press, UK, February 2016.
- Minxian Xu, Amir Vahid Dastjerdi, and Rajkumar Buyya, Energy Efficient Scheduling of Cloud Application Components with Brownout, IEEE Transactions on Sustainable Computing (T-SUSC), Volume 1, Number 2, Pages: 40-53, ISSN: 2377-3782, IEEE Computer Society Press, USA, July-Dec. 2016.

CloudSim: A Framework for Modeling and Simulation of Cloud Computing Infrastructures and Services

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

Cloud computing emerged as the leading technology for delivering reliable, secure, fault-tolerant, sustainable, and scalable computational services, which are presented as Software, Infrastructure, or Platform as services (SaaS, IaaS, PaaS). Moreover, these services may be offered in private data centers (private clouds), may be commercially offered for clients (public clouds), or yet it is possible that both public and private clouds are combined in hybrid clouds.

These already wide ecosystem of cloud architectures, along with the increasing demand for energy-efficient IT technologies, demand timely, repeatable, and controllable methodologies for evaluation of algorithms, applications, and policies before actual development of cloud products. Because utilization of real testbeds limits the experiments to the scale of the testbed and makes the reproduction of results an extremely difficult undertaking, alternative approaches for testing and experimentation leverage development of new Cloud technologies.

A suitable alternative is the utilization of simulations tools, which open the possibility of evaluating the hypothesis prior to software development in an environment where one can reproduce tests. Specifically in the case of Cloud computing, where access to the infrastructure incurs payments in real currency, simulation-based approaches offer significant benefits, as it allows Cloud customers to test their services in repeatable and controllable environment free of cost, and to tune the performance bottlenecks before deploying on real Clouds. At the provider side, simulation environments allow evaluation of different kinds of resource leasing scenarios under varying load and pricing distributions. Such studies could aid the providers in optimizing the resource access cost with focus on improving profits. In the absence of such simulation platforms, Cloud customers and providers have to rely either on theoretical and imprecise evaluations, or on try-and-error approaches that lead to inefficient service performance and revenue generation.

The primary objective of this project is to provide a generalized and extensible simulation framework that enables seamless modeling, simulation, and experimentation of emerging Cloud computing infrastructures and application services. By using CloudSim, researchers and industry-based developers can focus on specific system design issues that they want to investigate, without getting concerned about the low level details related to Cloud-based infrastructures such as Virtual Machines and Containers. CloudSim now support simulation of SDN and containers.

Some References:

- 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.
- Jungmin Son, Amir Vahid Dastjerdi, Rodrigo N. Calheiros, Xiaohui Ji, Young Yoon, and Rajkumar Buyya, CloudSimSDN: Modeling and Simulation of Software-Defined Cloud Data Centers, Proceedings of the 15th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid 2015), Shenzhen, China, May 4-7, 2015.
- Sareh Fotuhi Piraghaj, Amir Vahid Dastjerdi, Rodrigo N. Calheiros, and Rajkumar Buyya, ContainerCloudSim: An Environment for Modeling and Simulation of Containers in Cloud Data Centers, Software: Practice and Experience, Volume 47, Number 4, Pages: 505-521, ISSN: 0038-0644, Wiley Press, New York, USA, April 2017.

iFogSim: A Toolkit for Modeling and Simulation of Resource Management Techniques in Internet of Things, Edge and Fog Computing Environments

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

Internet of Things (IoT) aims to bring every object (e.g. smart cameras, wearable, environmental sensors, home appliances, and vehicles) online, hence generating massive amounts of data that can overwhelm storage systems and data analytics applications. Cloud computing offers services at the infrastructure level that can scale to IoT storage and processing requirements. However, there are applications such as health monitoring and emergency response that require low latency, and delay caused by transferring data to the cloud and then back to the application can seriously impact their performances. To overcome this limitation, Fog computing paradigm has been proposed, where cloud services are extended to the edge of the network to decrease the latency and network congestion.

To realize the full potential of Fog and IoT paradigms for real-time analytics, several challenges need to be addressed. The first and most critical problem is designing resource management techniques that determine which modules of analytics applications are pushed to each edge device to minimize the latency and maximize the throughput. To this end, we need an evaluation platform that enables the quantification of performance of resource management policies on an IoT or Fog computing infrastructure in a repeatable manner.

We developed a simulator, called iFogSim, to model IoT and Fog environments and measure the impact of resource management techniques in terms of latency, network congestion, energy consumption, and cost.

Some References:

- Harshit Gupta, Amir Vahid Dastjerdi, Soumya K. Ghosh, and Rajkumar Buyya, iFogSim: A Toolkit for Modeling and Simulation of Resource Management Techniques in Internet of Things, Edge and Fog Computing Environments, *Software: Practice and Experience (SPE)*, Volume 47, Issue 9, Pages: 1275-1296, ISSN: 0038-0644, Wiley Press, New York, USA, September 2017.
- Luiz F. Bittencourt, Javier Diaz-Montes, Rajkumar Buyya, Omer F. Rana, and Manish Parashar, Mobility-aware Application Scheduling in Fog Computing, *IEEE Cloud Computing*, Volume 4, No. 2, Pages: 34-43, ISSN: 2325-6095, IEEE Computer Society Press, USA, March-April 2017.
- Redowan Mahmud, Kotagiri Ramamohanarao, and Rajkumar Buyya, Fog Computing: A Taxonomy, Survey and Future Directions, *Internet of Everything: Algorithms, Methodologies, Technologies and Perspectives*, B. DiMartino, K. Li, L. Yang, A. Esposito (eds), 103-130pp, ISBN 978-981-10-5860-8, Springer, Singapore, October 2017.

9. Moments with Visitors, Colleagues and International Hosts



March 27, 2017: Prior to Delivering Distinguished Lecture at the University of Hyderabad, Hyderabad, India.



During CCGrid 2017 Inauguration, Madrid, Spain.



With Prof Aad van Moorsel, Head of School of Computing Science, Newcastle University, UK
after my seminar on May 22, 2017.



A conference in Bali, Indonesia (September 2016)



A snap of CLOUDS lab members taken during Bowen's PhD completion seminar (Nov 2016)



During a Scopus Researcher of the Year 2017 Awards, Sydney (Nov 2017)