Quantum Cloud Computing and Distributed Systems (qCLOUDS) Laboratory

www.cloudbus.org

Annual Report - 2025

School of Computing and Information Systems

Faculty of Engineering and Information Technology

The University of Melbourne, Australia

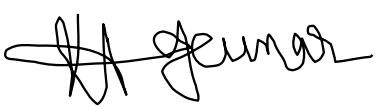
1. Director's Message

I am pleased to report on the key activities and outcomes of **Q**uantum **Clou**d Computing and **D**istributed **S**ystems (qCLOUDS) Laboratory at the University of Melbourne, Australia during the academic year 2025, 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 our research activities and outcomes in 2025 are:

- The Lab successfully carried out ARC Discovery Project along with involvement in two large projects (especially Zero Net Emissions CRC for Agriculture and SPARC (Scheme for Promotion of Academic and Research Collaboration)).
- Members of the CLOUDS Lab have authored 69 publications, which include 43 journal papers and 15 conference papers.
- The Lab's flagship Cloudbus Project has released various new modules for CloudSim, iFogSim, and Fogbus. iFogSim, building on CloudSim, has emerged as a de-facto toolkit for modelling and simulation of Fog and Edge computing environments. We released two new Quantum computing software systems (qFaaS and iQuantum); also released Murmura and iAnomaly softwares. They have been used by several researchers in academia and industries around the world.
- Members have presented over 47 invited talks that include 20 keynotes delivered at international conferences/events held in Australia, New Zealand, USA, India, China, Thailand, and Spain.
- The Lab successfully hosted research activities of over 25 scholars, which include 19 PhD students and 5 Visiting Research Fellows.
- One of our work received "Best Paper Award" from the 37th International Conference on Advanced Information Systems Engineering, Vienna, Austria, June 16-20, 2025
- A list of the world's top 2% researchers complied by Stanford University after assessing scientists worldwide for research carried out over their careers across all disciplines ranks us as #1 for citation impact for both single calendar year 2024 and #2 career-long in Distributed Computing area.
- Members of the Lab have led community efforts such as (a) the organisation of conferences (e.g., ICCCN 2025 in Japan) and (b) Editor-In-Chief of Journal of Software: Practice and Experience, which was established 55+ years ago.
- ACM has recognised our team member (Director) as its Fellow (class 2025).

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,



Dr. Rajkumar Buyya, Redmond Barry Distinguished Professor
Director, Quantum Cloud Computing and Distributed Systems (qCLOUDS) Laboratory
School of Computing and Information Systems
The University of Melbourne, Australia
Web: www.cloudbus.org

2. The Team

Director:

- Professor Rajkumar Buyya

Research/Academic Staff:

- Dr. Maria Rodriguez
- Dr. Muhammed Tawfiqul Islam
- Dr. Mohammad Goudarzi

PhD Students

- Mr. Jie Zhao
- Mr. Ming Chen
- Mr. Zhiyu Wang
- Ms. Duneesha Fernando
- Ms. Thakshila Imiya Mohottige
- Ms. Niloofar Gholipour
- Mr. Qifan Deng
- Mr. TianYu Qi
- Mr. Hootan Zhian
- Mr. Murtaza Rangwala
- Mr. Vivek Shukla
- Mr. Yifan Sun,
- Mr. Prabhjot Singh
- Mr. Haoyu Bai
- Mr. Abhishek Sawaika
- Mr. Avishka Sandeepa

Collaborators

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

International Visitors

- Chuanxiu Xi, Beijing University of Posts and Telecommunications, Beijing, China, Sept. 2025-Sept 2026.
- Qiqi Cai, Shanghai Jiao Tong University, Shanghai, China, Oct. 2025-Sept 2026.
- Anshul Verma, Banaras Hindu University (BHU), Varanasi, India, Sept. 2025-Sept. 2026.
- Rojalini Tripathy, Indian Institute of Technology, Bhubaneswar, India, Dec. 2025-March 2026.
- Divyansh Srivastava, Indian Institute of Technology, Bhubaneswar, India, Dec. 2025-March 2026.

3. Competitive Grants Funded Projects and Programs - Active

Australian Research Council (ARC)

- M. Gong; H. Bondell, R. Buyya, and K. Zhang, Causal Knowledge-Empowered Adaptive Federated Learning, Discovery Project, Australian Research Council (ARC), 2024-2026. Amount: $506,145

Other National Grants

- S. Ghosh (Indian lead) and R. Buyya (Australian lead), "AI-based Framework for Personalized Smart Healthcare using Edge-Cloud Platform", SPARC (Scheme for Promotion of Academic and Research Collaboration), Ministry of Education, Government of India, June 2024-May 2026, Amount: Indian Rupees 68.1 Lakh (68,10,000). AUD 126,100.
- R. Buyya, “Methods for Quantum Computing Application Deployment”, Centre for Australia-India Relations, Department of Foreign Affairs and Trade, Australia, 2025-2028. Amount $217,354.

Industry and Melbourne University Grants

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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	'18	'19	'20	'21	'22	'23	'24	'25
Books/Proceedings	1	1	1	1	5	4	3	5	2	3	2	2	1	2	3	1	2	2	4	8	5	2	4	5
Journal Papers	6	1	4	5	6	4	10	13	8	9	15	17	17	17	24	31	43	47	36	42	52	26	36	43
Book Chapters	1	0	0	4	4	2	4	11	3	13	3	1	2	3	6	10	1	8	3	9	9	2	4	6
Conference Papers	4	7	9	16	15	24	22	27	15	14	12	6	14	21	9	11	15	20	12	10	3	10	14	15
Magazine Articles	0	0	1	2	4	2	0	1	2	1	0	5	2	3	1	1	1	0	1	1	0	0	0	0
Total	12	9	15	28	34	36	39	57	30	40	32	31	36	46	43	54	62	77	58	70	69	40	58	69

Books/Proceedings Edited

1. Rajkumar Buyya and Sukhpal Singh Gill (eds), Quantum Computing: Principles and Paradigms, 252pp, ISBN: 978-0-443-29096-1, Morgan Kaufmann Press, Cambridge, MA 02139, USA, July 2025.
2. Sanjaya Kumar Panda, Rajkumar Buyya, Rashmi Ranjan Rout, Manjubala Bisi, Sangharatna Godboley, Kuan-Ching Li, and Ashish Ghosh (editors), Proceedings of the Third International Conference on Computing, Communication and Learning (CoCoLe 2024, Warangal, India, September 13-15, 2024), ISBN: 978-3-031-79040-9, Springer, Singapore, February 2025.
3. Anshul Verma, Pradeepika Verma, Kiran Kumar Pattanaik, Rajkumar Buyya, and Dipankar Dasgupta (eds.), Proceedings of the 4th International Conference on Advanced Network Technologies and Intelligent Computing (ANTIC 2024, Varanasi, India, December 19-21, 2024), ISBN: 978-3-031-83782-1, Springer, Switzerland, March 2025.
4. Alejandro C. Frery, Rajkumar Buyya, Ram Mohan Rao Kovvur, and T. Hitendra Sarma (editors), Proceedings of the International Conference on Computational Intelligence and Data Analytics (ICCIDA 2024, Hyderabad, India, June 28-29, 2024), ISBN: 978-981-96-0450-0, Springer, Switzerland, April 2025.
5. Debajyoti Misra, Mithun Chakraborty, Debashis De, and Rajkumar Buyya, Proceedings of the International Conference on Data Science and Communication (ICTDsC 2024, Siliguri, India, November 21-22, 2024), ISBN: 978-981-96-4542-8, Springer, Switzerland, September 2025.

Book Chapters

1. Muhammed Golec, Emir Sahin Hatay, Sukhpal Singh Gill, Ying Mao, and Rajkumar Buyya, Quantum Computing at a Glance, Quantum Computing: Principles and Paradigms, 3-18pp, R. Buyya and S. Gill (eds), ISBN: 978-0-443-29096-1, Morgan Kaufmann Press, Cambridge, MA 02139, USA, July 2025.
2. Hoa T. Nguyen, Bui Binh An Pham, Muhammad Usman, and Rajkumar Buyya, Quantum Serverless Paradigm and Application Development Using the QFaaS Framework, Quantum Computing: Principles and Paradigms, 139-164pp, R. Buyya and S. Gill (eds), ISBN: 978-0-443-29096-1, Morgan Kaufmann Press, Cambridge, MA 02139, USA, July 2025.
3. Hoa T. Nguyen, Muhammad Usman, and Rajkumar Buyya, QSimPy: A Learning-centric Simulation Framework for Quantum Cloud Resource Managementk, Quantum Computing: Principles and Paradigms, 165-183pp, R. Buyya and S. Gill (eds), ISBN: 978-0-443-29096-1, Morgan Kaufmann Press, Cambridge, MA 02139, USA, July 2025.
4. Emir Sahin Hatay, Muhammed Golec, Hoa T. Nguyen, Sukhpal Singh Gill, Panos Patros, Minxian Xu, Manmeet Singh, Omer Rana, Ajith Abraham, Junaid Qadir, Soumya K. Ghosh, Hanan Lutfiyya, Rizos Sakellariou, Salil S. Kanhere, Rami Bahsoon, Steve Uhlig, Ying Mao, and Rajkumar Buyya, Top Research Priorities in Quantum Computing, Quantum Computing: Principles and Paradigms, 221-

239pp, R. Buyya and S. Gill (eds), ISBN: 978-0-443-29096-1, Morgan Kaufmann Press, Cambridge, MA 02139, USA, July 2025.

5. Md. Hasanul Ferdaus, Fares Alharbi, Savitri Bevinakoppa, Md. Sawkat Ali, Mohammad Manzurul Islam, Maheen Islam, Taskeed Jabid, Sadia Nur Amin, and Rajkumar Buyya, Responsible IoHT Ecosystem for Smart Healthcare, Cybersecurity for Internet of Health Things, 223-288pp, M. Ahmed and N. Choudhury (eds), ISBN: 978-1-003-48326-7, CRC Press, USA, November 2025.
6. Md. Hasanul Ferdaus, Fares Alharbi, Mohammad Rifat Ahmmad Rashid, Md. Mostofa Kamal Rasel, Taskeed Jabid, Md. Sawkat Ali, Mohammad Manzurul Islam, Maheen Islam, and Rajkumar Buyya, Artificial Intelligence, Privacy, Governance, and Ethics for the Internet of Healthcare Things, Cybersecurity for Internet of Health Things, 289-2306pp, M. Ahmed and N. Choudhury (eds), ISBN: 978-1-003-48326-7, CRC Press, USA, November 2025.

Journal Papers

1. Shinu M. Rajagopal, Supriya M., and Rajkumar Buyya, Leveraging Blockchain and Federated Learning in Edge-Fog-Cloud Computing Environments for Intelligent Decision-Making with ECG Data in IoT, Journal of Network and Computer Applications (JNCA), Volume 233, Pages: 1-16, ISSN: 1084-8045, Elsevier, Amsterdam, The Netherlands, January 2025.
2. Nivedita Singh, Rajkumar Buyya, and Hyoungshick Kim, Securing Cloud-Based Internet of Things: Challenges and Mitigations, Journal of Sensors, Volume 25, Number 1, Pages: 1-45, ISSN: 1424-8220, MDPI Press, Basel, Switzerland, January 2025.
3. Guangyao Zhou, Wenhong Tian, Rajkumar Buyya and Kui Wu, UMPIPE: Unequal Microbatches-based Pipeline Parallelism for DNN Training, IEEE Transactions on Parallel and Distributed Systems (TPDS), Volume 36, No. 2, Pages: 293-307, ISSN: 1045-9219, IEEE CS Press, USA, February 2025.
4. Xinglei Chen, Zinuo Cai, Hanwen Zhang, Ruhui Ma, Rajkumar Buyya FasDL: An Efficient Serverless-based Training Architecture with Communication Optimization and Resource Configuration, IEEE Transactions on Computers (TC), Volume 74, No. 2, Pages: 468-482, ISSN: 0018-9340, IEEE CS Press, Los Alamitos, CA, USA, February 2025.
5. Renjun Zhang, Tianming Zhang, Zinuo Cai, Dongmei Li, Ruhui Ma, and Rajkumar Buyya, MemoriaNova: Optimizing Memory-Aware Model Inference for Edge Computing, ACM Transactions on Architecture and Code Optimization (TACO), Volume 22, Number 1, Article No. 3, Pages: 1-25, ISSN:1544-3566, ACM Press, New York, USA, March 2025.
6. Anupama Mampage, Shanika Karunasekera, and Rajkumar Buyya, Deep Reinforcement Learning for Scheduling Applications in Serverless and Serverful Hybrid Computing Environments, IEEE Transactions on Services Computing (TSC), Volume 18, Number 2, Pages: 718-728, ISSN: 1939-1374, IEEE Computer Society Press, USA, March-April 2025.
7. Zhiyu Wang, Mohammad Goudarzi, and Rajkumar Buyya, TF-DDRL: A Transformer-enhanced Distributed DRL Technique for Scheduling IoT Applications in Edge and Cloud Computing Environments, IEEE Transactions on Services Computing (TSC), Volume 18, Number 2, Pages: 1039-1053, ISSN: 1939-1374, IEEE Computer Society Press, USA, March-April 2025.

8. Vamshi Sunku Mohan, Sriram Sankaran, Rajkumar Buyya, and Krishnashree Achuthan, Leveraging Fog Computing for Security-Aware Resource Allocation in Narrowband Internet of Things, Software: Practice and Experience (SPE), Volume 55, Issue 4, Pages: 611-788, ISSN: 0038-0644, Wiley Press, New York, USA, April 2025.
9. N Sethu Subramanian, Prabhakar Krishnan, Kurunandan Jain, KB Aneesh Kumar, Tulika Pandey, and Rajkumar Buyya, Blockchain and RL-Based Secured Task Offloading Framework for Software-Defined 5G Edge Networks, IEEE Access, Volume 13, Pages: 56820-56842, ISSN: 2169-3536, IEEE Press, New Jersey, USA, April 2025.
10. Dawei Sun, Yinuo Fan, Chengjun Guan, Jia Rong, Shang Gao, and Rajkumar Buyya, An Elastic Reconfiguration Strategy for Operators in Distributed Stream Computing Systems, The Journal of Supercomputing, Volume 81, Number 5, Pages: 1-31, ISSN: 0920-8542, Springer Science+Business Media, Berlin, Germany, April 2025.
11. Ali Zahir, Ashiq Anjum, Satish Narayana Srirama, and Rajkumar Buyya, SAS: Speculative Locality Aware Scheduling for I/O Intensive Scientific Analysis in Clouds, Future Generation Computer Systems (FGCS), Volume 166, Pages: 1-14, ISSN: 0167-739X, Elsevier Press, Amsterdam, The Netherlands, May 2025.
12. Minghui Wu, Dawei Sun, Shang Gao, and Rajkumar Buyya, Straggler Mitigation via Hierarchical Scheduling in Elastic Stream Computing Systems, Future Generation Computer Systems (FGCS), Volume 166, Pages: 1-15, ISSN: 0167-739X, Elsevier Press, Amsterdam, The Netherlands, May 2025.
13. Han Wang, Kumar Ankur Anurag, Amira Rayane Benamer, Priyansh Arora, Gurleen Wander, Mark R. Johnson, Ranjit Mohan Anjana, Viswanathan Mohan, Sukhpal Singh Gill, Steve Uhlig, and Rajkumar Buyya, HealthAIoT: AIoT-driven Smart Healthcare System for Sustainable Cloud Computing Environments, Internet of Things, Volume 31, Pages: 1-23, ISSN: 2542-6605, Elsevier, Amsterdam, The Netherlands, May 2025.
14. Haitao Yuan, Qinglong Hu, Shen Wang, Jing Bi, Rajkumar Buyya, Jinhu Lü, Jinhong Yang, Jia Zhang, and MengChu Zhou, Cost-optimized Task Offloading for Dependent Applications in Collaborative Edge and Cloud Computing, IEEE Internet of Things Journal, Volume 12, Number 9, Pages: 12975-12988, ISSN: 2327-4662, IEEE Computer Society Press, USA, May 2025.
15. Junhan Liu, Zinuo Cai, Yumou Liu, Hao Li, Zongpu Zhang, Ruhui Ma, and Rajkumar Buyya, SMORE: Enhancing GPU Utilization in Deep Learning Clusters by Serverless-based Co-location Scheduling, IEEE Transactions on Parallel and Distributed Systems (TPDS), Volume 36, No. 5, Pages: 903-917, ISSN: 1045-9219, IEEE CS Press, USA, May 2025.
16. K. B. Aneesh Kumar, L. S. Mohith, Kurunandan Jain, Prabhakar Krishnan, Natarajan Venkatachalam, and Rajkumar Buyya, Post-Quantum Cryptography-Based Multimedia Encryption Communication Scheme in IoT Consumer Electronics, IEEE Transactions on Consumer Electronics, Volume 71, Number 2, Pages: 4995-5006, ISSN: 0098-3063, IEEE Press, USA, May 2025.
17. Anjum Mohd Aslam, Rajat Chaudhary, Aditya Bhardwaj, Neeraj Kumar, and Rajkumar Buyya, Digital Twins-enabled Game Theoretical Models and Techniques for Metaverse Connected and Autonomous Vehicles: A Survey, Journal of Network and Computer Applications (JNCA), Volume 238, Pages: 1-42, ISSN: 1084-8045, Elsevier, Amsterdam, The Netherlands, June 2025.
18. Jing Bi, Ziqi Wang, Haitao Yuan, Xiankun Shi, Ziyue Wang, Jia Zhang, MengChu Zhou, and Rajkumar Buyya, Large AI Models and Their Applications: Classification,

Limitations, and Potential Solutions, Software: Practice and Experience (SPE), Volume 55, Issue 6, Pages: 1003-1017, ISSN: 0038-0644, Wiley Press, New York, USA, June 2025.
19. Remo Andreoli, Jie Zhao, Tommaso Cucinotta, and Rajkumar Buyya, CloudSim 7G: An Integrated Toolkit for Modeling and Simulation of Future Generation Cloud Computing Environments, Software: Practice and Experience (SPE), Volume 55, Issue 6, Pages: 1041-1058, ISSN: 0038-0644, Wiley Press, New York, USA, June 2025.
20. Haitao Yuan, Qinglong Hu, Meijia Wang, Shen Wang, Jing Bi, Rajkumar Buyya, Shuyuan Shi, Jinhong Yang, Jia Zhang, and MengChu Zhou, Data-Filtered Prediction With Decomposition and Amplitude-Aware Permutation Entropy for Workload and Resource Utilization in Cloud Data Centers, IEEE Internet of Things Journal, Volume 12, Number 12, Pages: 19189-19201, ISSN: 2327-4662, IEEE Computer Society Press, USA, June 2025.
21. Duneesha Fernando, Maria A. Rodriguez, Patricia Arroba, Leila Ismail, and Rajkumar Buyya, Efficient Training Approaches for Performance Anomaly Detection Models in Edge Computing Environments, ACM Transactions on Autonomous and Adaptive Systems (TAAS), Volume 20, Number 2, Article No. 13, Pages: 1-27, ISSN:1556-4665, ACM Press, New York, USA, June 2025.
22. Thakshila Imiya Mohottige, Artem Polyvyanyy, Colin Fidge, Rajkumar Buyya, and Alistair Barros, Reengineering Software Systems into Microservices: State-of-the-Art and Future Directions, Information and Software Technology Journal, Volume 183, Pages: 1-27, ISSN: 0950-5849, Elsevier Science, Amsterdam, The Netherlands, July 2025.
23. Anwesha Mukherjee and Rajkumar Buyya, Federated Learning Architectures: A Performance Evaluation With Crop Yield Prediction Application, Software: Practice and Experience (SPE), Volume 55, Issue 7, Pages: 1165-1184, ISSN: 0038-0644, Wiley Press, New York, USA, July 2025.
24. Dawei Sun, Jia Peng, Ting Zhu, Jonathan Kua, Shang Gao, and Rajkumar Buyya, Toward High-Availability Distributed Stream Computing Systems via Checkpoint Adaptation, Concurrency and Computation: Practice and Experience (CCPE), Volume 37, No. 15-17, Pages: 1-18, ISSN: 1532-0626, Wiley Press, New York, USA, July 2025.
25. Jiahui Zhai, Jing Bi, Haitao Yuan, Jia Zhang, and Rajkumar Buyya, Energy-Efficient and Latency-Aware Task Offloading for Industrial Cloud-Edge Systems With Heterogeneous CPUs and GPUs, IEEE Internet of Things Journal, Volume 12, Number 13, Pages: 25757-25772, ISSN: 2327-4662, IEEE Computer Society Press, USA, July 2025.
26. Tanushree Dey, Somnath Bera, Anwesha Mukherjee, Debashis De, and Rajkumar Buyya, FLyer: Federated Learning-based Crop Yield Prediction for Agriculture 5.0, IEEE Transactions on Artificial Intelligence (TAI), Volume 6, No. 7, Pages: 1943-1952, ISSN: 1063-6706, IEEE Press, New York, USA, July 2025.
27. Jalil Boudjadar, Saif Ul Islam, Rajkumar Buyya, Dynamic FPGA Reconfiguration for Scalable Embedded Artificial Intelligence (AI): A Co-Design Methodology for Convolutional Neural Networks (CNN) Acceleration, Future Generation Computer Systems (FGCS), Volume 169, Pages: 1-11, ISSN: 0167-739X, Elsevier Press, Amsterdam, The Netherlands, August 2025.
28. Guangyao Zhou, Yiqin Fu, Haocheng Lan, Yuanlun Xie, Wenhong Tian, Rajkumar Buyya, Jiahong Qian, and Teng Su, Cross-Search with Improved Multi-Dimensional Dichotomy-based Joint Optimization for Distributed Parallel Training

of DNN, IEEE Transactions on Parallel and Distributed Systems (TPDS), Volume 36, No. 8, Pages: 1680-1694, ISSN: 1045-9219, IEEE Press, USA, August 2025.
29. Tharindu B. Hewage, Shashikant Ilager, Maria A. Rodriguez, and Rajkumar Buyya, A Framework for Carbon-aware Real-Time Workload Management in Clouds using Renewables-driven Cores, IEEE Transactions on Computers (TC), Volume 74, No. 8, Pages: 2757-2771, ISSN: 0018-9340, IEEE CS Press, Los Alamitos, CA, USA, August 2025.
30. Minghui Wu, Dawei Sun, Shang Gao, Keqin Li, and Rajkumar Buyya, Ls-Stream: Lightening Stragglers in Join Operators for Skewed Data Stream Processing, IEEE Transactions on Computers (TC), Volume 24, No. 8, Pages: 2841-2855, ISSN: 0018-9340, IEEE CS Press, Los Alamitos, CA, USA, August 2025.
31. Liwei Lin, Rongbo Ma, Zejian Wang, Zinuo Cai, Haochen Xu, Baoheng Zhang, Ruhui Ma, and Rajkumar Buyya, HWDSQP: A Historical Weighted and Dynamic Scheduling Quantum Protocol to Enhance Communication Reliability, IEEE Journal on Selected Areas in Communications, Volume 43, No. 8, Pages: 2810-2824, ISSN: 0733-8716, IEEE Communications Society Press, Los Alamitos, CA, USA, August 2025.
32. Yuze Du, Xiaogang Wang, Haokun Chen, Chenfeng Zhang, Jian Cao, and Rajkumar Buyya, SDRM: A Truncated SVD-based Bimensionality Reduction Approach to Efficient Edge Inference in Multi-head Attention Networks, Knowledge-Based Systems, Volume 325, Pages: 1-13, ISSN: 0950-7051, Elsevier, Amsterdam, The Netherlands, September 2025.
33. Moumita Mishra, Soumya Kanti Ghosh, Bhargab Maitra, and Rajkumar Buyya, Early Response Framework for Accident Detection and Prevention Through Multi-Zone Fog-Cloud Collaboration for Safety-Critical Applications, Software: Practice and Experience (SPE), Volume 55, Issue 9, Pages: 1616-1634, ISSN: 0038-0644, Wiley Press, New York, USA, September 2025.
34. Jing Bi, Xiangxi Wu, Haitao Yuan, Ziqi Wang, Damien Wei, Renren Wu, Jia Zhang, Junfei Qiao, and Rajkumar Buyya, STMF: A Spatio-Temporal Multimodal Fusion Model for Long-term Water Quality Forecasting, IEEE Internet of Things Journal, Volume 12, Number 18, Pages: 37146-37159, ISSN: 2327-4662, IEEE Computer Society Press, USA, September 2025.
35. Lingxiao Jin, Zinuo Cai, Haoxin WANG, Zongpu Zhang, Ruhui Ma, Haibing Guan, Yuan Liu, and Rajkumar Buyya, Ephemera: Accelerating I/O-Intensive Serverless Workloads with a Harvested In-memory File System, ACM Transactions on Architecture and Code Optimization (TACO), Volume 22, Number 3, Article No. 102, Pages: 1-24, ISSN:1544-3566, ACM Press, New York, USA, September 2025.
36. Zhicheng Cai, Hang Wu, Xu Jiang, Xiaoping Li, and Rajkumar Buyya, Deep Learning and Feedback Control Based Container Auto-scaling for Cloud Native Micro-services, IEEE Transactions on Services Computing (TSC), Volume 18, Number 5, Pages: 2714-2725, ISSN: 1939-1374, IEEE Computer Society Press, USA, Sept.-Oct. 2025.
37. Zhiyu Wang, Mohammad Goudarzi, and Rajkumar Buyya, ReinFog: A Deep Reinforcement Learning Empowered Framework for Resource Management in Edge and Cloud Computing Environments, Journal of Network and Computer Applications (JNCA), Volume 242, Pages: 1-20, ISSN: 1084-8045, Elsevier, Amsterdam, The Netherlands, October 2025.
38. Jiayi Li, Xiaogang Wang, Haokun Chen, Zexin Wu, Ziqi Zhu, Jian Cao, and Rajkumar Buyya, DGPAS: DQN-GRU guided distributed DNN pipeline training and adjacent scheduling in edge networks, Computer Networks, Volume 271,

Pages: 1-14, ISSN: 1389-1286, Elsevier Press, Amsterdam, The Netherlands, October 2025.

39. Anupama Mampage, Shanika Karunasekera, and Rajkumar Buyya, A Deep Reinforcement Learning based Algorithm for Time and Cost Optimized Scaling of Serverless Applications, Future Generation Computer Systems (FGCS), Volume 173, Pages: 1-14, ISSN: 0167-739X, Elsevier Press, Amsterdam, The Netherlands, December 2025.
40. Muhammed Golec, Emir Sahin Hatay, Sukhpal Singh Gill, and Rajkumar Buyya, Artificial Intelligence (AI): Foundations, Trends and Future Directions, Telematics and Informatics Reports, Volume 20, Pages: 1-9, ISSN: 0736-5853, Elsevier Press, Amsterdam, The Netherlands, December 2025.
41. Saumya Priyadarshini, Chandrashekar Jatoth, Rajesh Doriya, and Rajkumar Buyya, Optimizing Qubit Transfer in Multi-host Quantum Network Using Security-Oriented Entanglement Routing Algorithm, Optics Communications Journal, Volume 596, Pages: 1-12, ISSN: 0030-4018, Elsevier Press, Amsterdam, The Netherlands, December 2025.
42. Minghui Wu, Dawei Sun, Shang Gao, and Rajkumar Buyya, A Hierarchical Near-Source Grouping Strategy for Elastic Stream Computing Systems, IEEE Transactions on Services Computing (TSC), Volume 18, Number 6, Pages: 3378-3391, ISSN: 1939-1374, IEEE Computer Society Press, USA, November/December 2025.
43. Guangyao Zhou, Minxian Xu, Jiashu Zhang, Rajkumar Buyya, GMHA: Growable Meta-Heuristic Algorithm for Multi-Objective Optimization Problems and its Application in Cloud Scheduling, IEEE Transactions on Services Computing (TSC), Volume 18, Number 6, Pages: 3850-3864, ISSN: 1939-1374, IEEE Computer Society Press, USA, November/December 2025.

Conference Papers

1. Joao Bachiega Jr, Breno Costa, Michel J. F. Rosa, Leonardo R. Carvalho, Marcelo A. Marotta, Aleteia Araujo and Rajkumar Buyya, An Effective Resource Discovery Strategy for Fog Computing Driven by Computational Capabilities and Behavioral Characteristics, Proceedings of the 10th International Congress on Information and Communication Technology (ICICT 2025, Springer, Germany), London, United Kingdom, February 18-21, 2025.
2. Murtaza Rangwala and Rajkumar Buyya, TrustMesh: A Blockchain-Enabled Trusted Distributed Computing Framework for Open Heterogeneous IoT Environments, Proceedings of the 22nd IEEE International Conference on Software Architecture (ICSA 2025, IEEE CS Press, USA), Odense, Denmark, March 31-April 4, 2025.
3. Tianyu Qi, Maria A. Rodriguez, and Rajkumar Buyya, ScalaSSC: Scalable Stateful Serverless Computing for Stream Processing Applications, Proceedings of the 25th IEEE International Symposium on Cluster, Cloud, and Internet Computing (CCGrid 2025, IEEE CS Press, USA), Tromso, Norway, May 19-22, 2025.
4. Hootan Zhian, Rajkumar Buyya, and Artem Polyvyanyy, Federated Stochastic Process Discovery Using Grammatical Inference, Proceedings of the 37th International Conference on Advanced Information Systems Engineering (CAiSE 2025, Springer, Germany), Vienna, Austria, June 16-20, 2025. **- Best Paper Award**.

5. Tharindu B. Hewage, Shashikant Ilager, Maria Rodriguez Read, and Rajkumar Buyya, Aging-aware CPU Core Management for Embodied Carbon Amortization in Cloud LLM Inference, Proceedings of the 16th ACM International Conference on Future and Sustainable Energy Systems (E-ENERGY 2025, ACM Press, USA), Rotterdam, Netherlands, June 17-20, 2025.
6. Hootan Zhian, Rajkumar Buyya, and Artem Polyvyanyy, Multi-Objective Metaheuristics for Effective and Efficient Stochastic Process Discovery, Proceedings of the 23rd International Conference on Business Process Management (BPM 2025), Seville, Spain, August 31-September 5, 2025.
7. Jiahui Zhai, Jing Bi, Haitao Yuan, Ziqi Wang, Jia Zhang and Rajkumar, Buyya, Integrated CPU-GPU Task Scheduling for Energy Efficiency and Low Latency in Heterogeneous Industrial IoT Systems, Proceedings of the 34th International Conference on Computer Communications and Networks (ICCCN 2025, IEEE Press, USA), Tokyo, Japan, August 4-7, 2025.
8. Vineet Dwivedi, Chandrashekar Jatoth, Vivek Sukla, and Rajkumar Buyya, Energy Efficient Quantum Entanglement Generation Optimizing Resource Utilization in Large Network, Proceedings of the 34th International Conference on Computer Communications and Networks (ICCCN 2025, IEEE Press, USA), Tokyo, Japan, August 4-7, 2025.
9. Zhaojun Wang, Dawei Sun, Xuan Zang, Atul Sajjanhar, and Rajkumar Buyya, Dynamic Adaptive Fault-Tolerance in Stream Computing Systems Under Resource Constraints, Proceedings of the 25th International Conference on Algorithms and Architectures for Parallel Processing (ICA3PP 2025, Springer, Germany), Zhengzhou, Henan, China, October 30-November 02, 2025.
10. Yinuo Fan, Dawei Sun, Shuaiyi Zou, Jonathan Kua, and Rajkumar Buyya, Hierarchical Dependency-Aware Scheduling for Distributed Stream Computing Systems, Proceedings of the 25th International Conference on Algorithms and Architectures for Parallel Processing (ICA3PP 2025, Springer, Germany), Zhengzhou, Henan, China, October 30-November 02, 2025.
11. Jie Zhao and Rajkumar Buyya, gCloudSim: A GPU Accelerated Simulator for Learning-driven Cloud Resource Optimisation, Proceedings of the 26th International Conference on Parallel and Distributed Computing (PDCAT 2025), Applications and Technologies (PDCAT 2025, Springer, Germany), Gold Coast, Australia, November 22-24, 2025.
12. Siddharth Agarwal, Maria A. Rodriguez, and Rajkumar Buyya, Serv-Drishti: An Interactive Serverless Function Request Simulation Engine and Visualiser, Proceedings of the 35th International Telecommunication Network and Applications Conference (ITNAC 2025, IEEE Press, USA), Christchurch, New Zealand, November 26-28, 2025.
13. Vineet Kumar Dwivedi, Vivek Shukla, Chandrashekar Jatoth, Rajesh Doriya, and Rajkumar Buyya, SPEP: Adaptive Resource Orchestration in Quantum Networks through Strategic Entanglement Pre-Positioning, Proceedings of the 35th International Telecommunication Network and Applications Conference (ITNAC 2025, IEEE Press, USA), Christchurch, New Zealand, November 26-28, 2025.
14. Saumya Priyadarshini, Chandrashekar Jatoth, Rajesh Doriya, and Rajkumar Buyya, Hierarchical Quantum Backbone: A Scalable and Robust Topology for Quantum Network, Proceedings of the 35th International Telecommunication Network and Applications Conference (ITNAC 2025, IEEE Press, USA), Christchurch, New Zealand, November 26-28, 2025.
15. Minghui Wu, Dawei Sun, Xiaoxian Wang, Shang Gao, and Rajkumar Buyya, A Prediction-Driven Collaborative Scheduling Strategy for Distributed Stream

Computing Systems, Proceedings of the 31st IEEE International Conference on Parallel and Distributed Systems (ICPADS 2025, IEEE Press, USA), Hefei, China, December 14-17 2025.

5. Invited Presentations and Outreach

By the Lab Director:

Keynote Talks at International Conferences

1. 21st International Conference on Distributed Computing and Intelligent Technology (ICDCIT 2025), Bhubaneswar, India, January 8-11, 2025.
2. First International Conference on Advances in Smart Computing and Applications (ICASCA-2025), Ahmedabad, India, February 15-16, 2025.
3. International conference of Web 6.0 and Industry 6.0 (WIn 2024), Kolkata, India, February 21-22, 2025.
4. 10th International Conference on Information and Network Technologies (ICINT 2025), Melbourne, Australia, March 12-14, 2025.
5. International Conference on Emerging Trends and Technologies on Intelligent Systems (ETTIS 2025), Noida, India, March 19-21, 2025.
6. International Conference on Sustainable Smart Computing and Communications (ICSSCC 2025), Pune, India, March 21-22, 2025.
7. FINDS: U.S. Army Funded Digital Forensics Center of Excellence Conference, Miami, Florida, USA, May 6, 2025.
8. Annual Modeling and Simulation Conference (ANNSIM 2025), Madrid, Spain, May 26-29, 2025.
9. 3rd International Conference on Big Data and Privacy Computing (BDPC 2025), Fuzhou, China, May 30-June 1, 2025.
10. QTRIC 2025 (Quantum Technology Research and Innovation Conference), Bangkok, Thailand, August 3-5, 2025.
11. 4th Annual Academic Conference on Network Computing, Xi'an, China, August 9-10, 2025.
12. 2025 China Digital Services Conference, Yantai, China, August 19-21, 2025.
13. 7th International Conference on Big-data Service and Intelligent Computation (BDSIC 2025), Bangkok, Thailand, October 29-31, 2025.
14. International Conference on Advances in Computational Intelligence and Applications (ICACIA 2025), Delhi, India, November 7-8, 2025.
15. International Conference on Satellite Computing ICSC 2025), Yantai, China, November 15-16, 2025.
16. 35th International Telecommunication Network and Applications Conference (ITNAC 2025, IEEE Press, USA), Christchurch, New Zealand, November 26-28, 2025.
17. 5th International Conference on Information Communication and Software Engineering (ICICSE 2025), Chongqing, China, December 12-14, 2025.
18. 15th International Conference on Applications and Techniques in Information Security (ATIS 2025), Melbourne, Australia, December 17-19, 2025.
19. International Conference on Quantum Technology and Applications (QUANTUMKOL-2025), Kolkata, India, December 17-19, 2025.
20. 3rd International Conference on Advanced Computing, Machine Learning, Robotics and Internet Technologies (AMRIT-2025), Assam University, Silchar & Diphu Campus, December 22-24, 2025.

National Conferences

1. Asian Summer School, Beihang University, Hangzhou, China, August 21, 2025.

2. International Workshop on Distributed Systems for LLMs, Macao, China, August 28-29, 2025.
3. IITBBS-TCS Certification Program on Cloud Systems and Infrastructure Management, IIT Bhubaneswar and Tata Consultancy Services (TCS), November 8, 2025

Seminars - in Cloud and Quantum Computing area:

1. Indian Institute of Technology, Kharagpur, India, January 3, 2025.
2. Indian Institute of Technology, Bhubaneshwar, India, January 5, 2025.
3. Indian Institute of Information Technology, Allahabad, Prayagraj, India, January 13, 2025.
4. National Institute of Technology, Raipur, India, January 15, 2025.
5. International Institute of Information Technology (IIIT), Naya Raipur, India, January 15, 2025.
6. Jamia Millia Islamia, New Delhi, India, February 4, 2025.
7. University of North Texas, Denton, USA, May 5, 2025.
8. Fordham University, New York, USA, May 9, 2025.
9. New Jersey Institute of Technology (NJIT), Newark, USA, May 12, 2025.
10. Rensselaer Polytechnic Institute (RPI), Troy, New York, USA, May 16, 2025.
11. University of Oslo, Oslo, Norway, May 23, 2025.
12. University of Sharjah, UAE, May 28, 2025.
13. Inner Mongolia University (IMU), Hohhot, China, August 11, 2025.
14. Beijing University of Posts and Telecommunications (BUPT), Beijing, China, August 13, 2025.
15. China University of Geosciences, Beijing, China, August 14, 2025.
16. Harbin Engineering University, Harbin, China, August 15, 2025.
17. Harbin Institute of Technology, Harbin, China, August 18, 2025.
18. Zhejiang University, Hangzhou, China, August 22, 2025.
19. Hangzhou Normal University, Hangzhou, China, August 22, 2025.
20. Hangzhou Dianzi University, Hangzhou, China, August 23, 2025.
21. Tongji University, Shanghai, China, August 25, 2025.
22. Shanghai Jiao Tong University (SJTU), Shanghai, China, August 26, 2025.
23. Fudan University, Shanghai, China, August 27, 2025.
24. Indian Institute of Science, Bengaluru, India, September 2, 2025.

6. Selected Community Services

By the Lab Director:

IEEE Computer Society

1. Advisory Board, IEEE Transactions on Cloud Computing (TCC)

Software: Practice and Experience (Wiley)

1. 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, 2013-to date.
2. Field Chief Editor, Frontiers in the Internet of Things, Frontiers Media, Lausanne, Switzerland, 2022 - to date.
3. Associate Editor, ACM Transactions on Autonomous and Adaptive Systems (TAAS), ISSN:1556-4665, ACM Press, New York, USA, 2024- 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 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.

Conference Organisation/Program Committee Memberships

1. Track Chair (Cloud and Distributed HPC), Supercomputing India (SCI 2025), December 9-13, 2025, Bengaluru, India.
2. Track Chair (Edge and Cloud Computing), 34th IEEE International Conference on Computer Communications and Networks (ICCCN 2025), August 4 - 7, 2025, Tokyo, Japan.
3. 26th International Conference on Parallel and Distributed Computing, Applications and Technologies (PDCAT 2025), November 22-24, 2025, Gold Coast, Australia.
4. IEEE International Conference on Cloud Computing (CLOUD 2025), July 7-12, 2025, Helsinki, Finland.

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: * Noted in their respective profile pages.

7. Members Profile and Activities

Member Profile: Ming Chen

I began my Ph.D. remotely in December 2020 due to COVID-19 border restrictions and arrived onshore in March 2022. I am supervised by Prof. Rajkumar Buyya, Dr. Maria Alejandra Rodriguez, and Dr. Tawfiq Islam.

Before beginning my Ph.D. journey, I completed my Bachelor's degree in Engineering at Hunan University in September 2016. I then worked as a research engineer and project manager at the Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, where I gained experience in areas including speech recognition, FinTech, and cloud robotics. My current research at the University of Melbourne focuses on microservice management, networking, and agentic systems.

Outside the lab, I enjoy playing tennis and snooker, as well as surfing and hiking.

Paper in 2025:
Chen, Ming, Muhammed Tawfiqul Islam, Maria Rodriguez Read, and Rajkumar Buyya. "**TraDE: Network and Traffic-aware Adaptive Scheduling for Microservices Under Dynamics**." in *IEEE Transactions on Parallel and Distributed Systems (*TPDS*)*, vol. 37, no. 1, pp. 76-89, Jan. 2026
Chen, Ming, Muhammed Tawfiqul Islam, Maria Rodriguez Read, and Rajkumar Buyya. "**TraDE: Network and Traffic-aware Adaptive Scheduling for Microservices Under Dynamics**." in *IEEE Transactions on Services Computing (*Under 1st revision)

For more information, please refer,
Linkedin : https://www.linkedin.com/in/ming-chen-6056b4b9/
Google Scholar : https://scholar.google.com.au/citations?user=KGdnd20AAAAJ&hl=en

Member Profile: Siddharth Agarwal

I joined CLOUDS lab as a Master of Science (Computer Science) student in March 2020, under the supervision of Dr. Buyya and Dr. Maria Rodriguez at The University of Melbourne.

Prior to joining the CLOUDS Lab Group, I received my Bachelor of Technology degree with Honours from Jaypee Institute of Information Technology (JIIT), India, where I gained initial experiences in the field of AI/ML along with practical implementations. After graduating, I worked with IBM India for 15 months as an Associate System Engineer at Bangalore, India, with a focus towards software development and management of CMS (Content Management System) applications.

I completed my MSc mostly from overseas (India) in 2021, obtaining a place in Dean's Honors List 2021 and was awarded a Melbourne Research Scholarship for my Doctoral program. I completed my PhD program in December 2025, and the degree is conferred in March 2026. As part of my PhD program, I explored the resource management and resource scheduling techniques, including the resource configuration and orchestration, in the domain of Serverless computing or Function-as-a-Service offering of Cloud Computing and investigated the application of AI/ML techniques for the same. My research focuses on data-driven and workload-aware function resource configurations and management.

For more information on my current research, publications and networking, please visit my website https://agarwalsiddharth.com and LinkedIn https://www.linkedin.com/in/siddharth26agarwal.

Member Profile: Zhiyu Wang

I am a PhD candidate at the qCLOUDS Lab, School of Computing and Information Systems, University of Melbourne, supervised by Professor Rajkumar Buyya, Dr. Mingming Gong, and Dr. Mohammad Goudarzi since 2022. Prior to my PhD, I obtained my Master's degree from the University of Melbourne in 2021, where I completed my thesis under the supervision of Professor Rajkumar Buyya.

My research focuses on developing AI-driven algorithms and systems for adaptive resource management across the IoT-Edge-Cloud computing continuum, with emphasis on Deep Reinforcement Learning, Federated Learning, and distributed optimization. My broader interests include cyber-physical systems, privacy and trustworthy computing, and foundation model-driven edge intelligence.

Selected Publications (2025):

- **Z. Wang**, M. Goudarzi, and R. Buyya, "TF-DDRL: A Transformer-Enhanced Distributed DRL Technique for Scheduling IoT Applications in Edge and Cloud Computing Environments," IEEE Transactions on Services Computing, vol. 18, no. 2, pp. 1039–1053, 2025.
- **Z. Wang**, M. Goudarzi, and R. Buyya, "ReinFog: A Deep Reinforcement Learning Empowered Framework for Resource Management in Edge and Cloud Computing Environments," Journal of Network and Computer Applications, vol. 242, Article 104250, 2025.
- **Z. Wang**, M. Goudarzi, M. Gong, and R. Buyya, "A Knowledge Distillation-Empowered Adaptive Federated Reinforcement Learning Framework for Multi-Domain IoT Applications Scheduling," arXiv preprint arXiv:2508.21328, 2025.
- **Z. Wang**, S. Raj, and R. Buyya, "AirFed: Federated Graph-Enhanced Multi-Agent Reinforcement Learning for Multi-UAV Cooperative Mobile Edge Computing," arXiv preprint arXiv:2510.23053, 2025.

For more details, feel free to visit my Google Scholar page or connect with me on LinkedIn.

Member Profile: Duneesha Fernando

I joined the qCLOUDS lab in April 2022 to pursue my PhD under the supervision of Prof. Rajkumar Buyya and Dr. Maria Read. I am currently in the final year of my PhD and plan to submit my thesis in March 2026. My doctoral research has been fully supported by the Melbourne Graduate Research Scholarship.

Prior to commencing my PhD, I completed my BSc (Hons) in Computer Science at the University of Colombo School of Computing (UCSC), Sri Lanka, in 2019. Following graduation, I worked as an Assistant Lecturer at UCSC for one year. I subsequently joined WSO2, the world's leading open-source integration vendor, where I worked in the research team for two years, first as a Research Engineer and later as a Senior Machine Learning Engineer.

My PhD research focuses on performance anomaly detection and diagnosis in microservices-based IoT applications deployed in edge computing environments. In particular, my work addresses the unique challenges involved in building autonomous anomaly-aware frameworks for managing large-scale microservices-based IoT applications across edge–cloud infrastructures. My research interests include performance anomaly detection and diagnosis, anomaly management, edge/cloud/fog computing, and microservices-based IoT systems.

Key outcomes of my PhD research to date include:

1) iAnomaly: A Toolkit for Generating Performance Anomaly Datasets in Edge-Cloud Integrated Computing Environments - Published in the 17th IEEE/ACM International Conference on Utility and Cloud Computing (UCC 2024) - https://ieeexplore.ieee.org/abstract/document/10971830

2) Efficient Training Approaches for Performance Anomaly Detection Models in Edge Computing Environments - Published in ACM Transactions on Autonomous and Adaptive Systems, March 2025 - https://dl.acm.org/doi/full/10.1145/3725736

3) A Decentralized Root Cause Localization Approach for Edge Computing Environments - Accepted for publication in IEEE Transactions on Services Computing, February 2026 - https://ieeexplore.ieee.org/document/11414199/

4) A Cascaded Graph Neural Network for Joint Root Cause Localization and Analysis in Edge Computing Environments – Under review at IEEE Transactions on Services Computing, March 2026 - https://arxiv.org/abs/2603.01447

For more information please refer,
Linkedin : https://www.linkedin.com/in/duneesha-fernando/
Google Scholar : https://scholar.google.com.au/citations?user=azM61FMAAAAJ&hl=en

Member Profile: Tianyu Qi

I joined the CLOUDS lab as a PhD student in June 2023 under the supervision of Dr. Maria Read and Prof. Rajkumar Buyya. I obtained my Bachelor of Engineering in Electronics Engineering from China Agricultural University in 2019 and my Master of Science in Computer Science from the University of Melbourne in 2021. Before joining CLOUDS lab, I worked in Industry as a Java Developer in my country.

In my master's degree, supervised by Dr. Maria Read, my research project topic is resource allocation for Distributed Stream Processing Systems. I am in the first year of my PhD study, whose research is on Serverless Computing for Stream Processing. My research aims to achieve lower latency and higher throughput for stream processing applications.

Publications:
Tianyu Qi and Maria Rodriguez. 2021. A Traffic and Resource Aware Online Storm Scheduler. In Proceedings of the 2021 Australasian Computer Science Week Multiconference (ACSW '21). Association for Computing Machinery, New York, NY, USA, Article 8, 1–10.

Email: tiqi@student.unimelb.edu.au

Member Profile: Qifan Deng

I obtained a Bachelor of Engineering and a Bachelor of Management at the Beijing Institute of Technology. After that, I worked as a research assistant in Beijing Measurement and Control Technology Lab, as an engineer at Intel Corporation, as a software engineer at Huawei, and as a digital analyst at McKinsey & Company.

I joined the CLOUDS Laboratory in November 2020, as a master majoring in computer science at University of Melbourne.

I am currently a PhD candidate under the supervision of Prof. Rajkumar Buyya, working on a scalable distributed framework for scheduling and processing Internet of Things requests.

I hope my work can help with people's efficiency and creativity, thus, leave a small footprint as a contribution to human civilization progress.

GitHub: https://github.com/pancak3
LinkedIn: https://linkedin.com/in/qifan-deng

Member Profile: Murtaza Rangwala

I am a Ph.D. candidate in the School of Computing and Information Systems at the University of Melbourne, affiliated with the qCLOUDS Lab and supervised by Professor Rajkumar Buyya and Professor Richard Sinnott. My research focuses on enhancing privacy and trust in distributed machine learning systems.

I joined the lab in 2024 and in that year, I developed TrustMesh, a blockchain-based framework for secure distributed computing in IoT environments which was accepted for publication at a reputable software architecture conference. In the following year, I focused my efforts on making distributed data parallel (DDP) learning more trustworthy and communication efficient. To support this work, I ended up developing Murmura, a peer-to-peer machine learning simulator to evaluate decentralized algorithms across network topologies and privacy constraints. My work is supported by the Melbourne Graduate Research Scholarship. I also volunteer as a Peer Reviewer for several Q1 journals and reputable conferences.

Prior to starting my PhD, I worked on modernizing cloud infrastructure and building scalable wealth management platforms as an Engineering Analyst at Goldman Sachs. I aim to advance distributed machine learning systems that prioritize privacy and trustworthiness, enabling entities to collaborate securely without compromising sensitive data.

Notable Work:

M. Rangwala, R. Buyya. “TrustMesh: A Blockchain-Enabled Trusted Distributed Computing Framework for Open Heterogeneous IoT Environments". Proceedings of the 22nd IEEE International Conference on Software Architecture (ICSA 2025). CORE A.

M. Rangwala, R. Sinnott, R. Buyya. "Evidential Trust-Aware Model Personalization in Decentralized Federated Learning for Wearable IoT". The 26th IEEE International Symposium on Cluster, Cloud, and Internet Computing (CCGrid 2026). Flagship Cloud Computing Conference.

M. Rangwala, F. Azzedin, R. Sinnott, R. Buyya. "SketchGuard: Scaling Byzantine-Robust Decentralized Federated Learning via Sketch-Based Screening". Preprint (Under Review). https://murtaza-hatim.com/publications/sketchguard

Profiles:
Website: https://www.murtaza-hatim.com
LinkedIn: https://www.linkedin.com/in/murtazahrangwala
GitHub: https://github.com/murtazahr

Member Profile: Prabhjot Singh

I am a PhD candidate in the School of Computing and Information Systems at the University of Melbourne, affiliated with the qCLOUDS Lab and supervised by Professor Rajkumar Buyya and A/Prof. Adel N. Toosi, where I began my doctoral studies in 2025. My research focuses on distributed quantum machine learning, exploring how large quantum learning models can be trained across multiple quantum processing units (QPUs) by partitioning and distributing quantum circuits. The goal of this work is to overcome current hardware limitations and enable scalable quantum machine learning systems.

My work investigates techniques for splitting large quantum circuits into smaller subcircuits, executing them across distributed quantum resources, and reconstructing the final computation with minimal overhead. By integrating circuit-cutting techniques with machine learning pipelines, I aim to enable the training of quantum models that exceed the qubit capacity of individual devices. This research studies the trade-offs between scalability, computational overhead, and model performance in distributed quantum learning environments.

Prior to my PhD, I completed a Master of Mathematics in Computer Science at the University of Waterloo, where my thesis examined website fingerprinting attacks in Low Earth Orbit satellite internet networks. I have also worked on interdisciplinary machine learning projects in cybersecurity and healthcare technologies.

My long-term goal is to advance scalable and trustworthy AI systems by bridging ideas from distributed systems, machine learning, and quantum computing.

LinkedIn: https://linkedin.com/in/singh-prabh

Member Profile: Haoyu Bai

I joined the qCLOUDS Lab in February 2025 to pursue my PhD under the supervision of Prof. Rajkumar Buyya and Dr. Tawfiq Islam. My PhD study is fully funded by the CSC Scholarship.

Prior to starting my PhD, I obtained a Bachelor of Science in Computing and a Master of Information Technology (majoring in Artificial Intelligence) from the University of Melbourne in 2021 and 2024, respectively. I also have over one year of research and industry experience at SIAT and CSG in China.

My research interests include Quantum Cloud Computing, Reinforcement Learning, Quantum Software Engineering, and Agentic Resource Management. My PhD focuses on developing agentic resource management frameworks for both classical containerized cloud systems and emerging quantum container infrastructures.

Paper in 2025:

H. Bai, M. T. Islam, M. Xu, and R. Buyya, ORACL: Optimized Reasoning for Autoscaling via Chain of Thought with LLMs for Microservices, *arXiv preprint arXiv:2602.05292*, 2026.

For more information, please refer,
Linkedin: www.linkedin.com/in/haoyu-bai-998226223

Research Visitor: Rojalini Tripathy

I joined the qCLOUDS Lab in December 2025 as an international research visitor under the supervision of Prof. Rajkumar Buyya. I am a Ph.D. scholar at the Indian Institute of Technology (IIT) Bhubaneswar, India. My visit to the University of Melbourne is supported by the SPARC (Scheme for Promotion of Academic and Research Collaboration) project.

My research area is Privacy-Preserving Federated Learning, with a special focus on making federated learning frameworks cost-effective, communication-efficient, and scalable while maintaining secure parameter transmission. In 2025, I proposed HalfFedLearn, a secure and cost-effective framework through selective security enforcement using homomorphic encryption. In another work, I integrated differential privacy mondrian clustering into a federated learning framework through a gossip protocol to make the clustering process in hierarchical setup privacy-preserving. In the qCLOUDS Lab, I am working on a personalised smart healthcare framework where multiple health organizations with multiple model objectives and feature disparity can collaboratively train.

Prior to my Ph.D., in 2022 I completed my master's from the Indian Institute of Technology (Indian School of Mines), Dhanbad. In 2019, I received my BTech degree from Parala Maharaja Engineering College, Odisha. For more details, feel free to visit my Google Scholar page or connect with me on LinkedIn.

Google Scholar: https://scholar.google.com/citations?user=FXrvZy8AAAAJ&hl=en&oi=ao
LinkedIn: https://www.linkedin.com/in/rojalini-tripathy-386b04159/

Research Visitor: Divyansh Srivastava

I joined the qCLOUDS Lab at the University of Melbourne in December 2025 as an international research visitor under the supervision of Prof. Rajkumar Buyya. I am currently pursuing my Ph.D. in Computer Science and Engineering at the Indian Institute of Technology (IIT) Bhubaneswar, India. My research visit is supported by the SPARC (Scheme for Promotion of Academic and Research Collaboration) project.

Prior to starting my Ph.D., I received my M.Tech. in Computer Science and Engineering from Pondicherry University in 2025, and my B.Tech. from the R.B.S. Engineering Technical Campus, Agra, in 2023.

My core research interests lie at the intersection of Natural Language Processing, Machine Learning, and Agentic AI. My past work has focused on building inclusive technology, notably developing applications integrating fine-tuned Large Language Models to enhance web accessibility for visually impaired users. This research culminated in the publication of my conference paper, "NAVIGATE: LLM-Based Web Content Summarization to Improve Accessibility for Persons with Visual Impairments".

During my visiting period at the qCLOUDS Lab, my research plan is to focus on Agentic AI in healthcare. I am currently architecting a multi-agent AI diagnostic system that utilizes collaborative clinical reasoning. This framework orchestrates a human-in-the-loop pipeline where specialized AI agents – a triage nurse, a diagnostician, and a safety supervisor – collaborate to gather patient histories, generate differential diagnoses with drug-interaction checks, and iteratively validate the safety of proposed medical plans.

For more information, please refer:

LinkedIn: https://www.linkedin.com/in/divyansh-s-649a1a13b/

Research Visitor: Dr. Anshul Verma

I am currently a Research Visitor at the qCLOUDS Lab, The University of Melbourne, from November 2025 to September 2026, collaborating with Prof. Rajkumar Buyya. This research visit is supported by the Institutions of Eminence (IoE) Scheme of Banaras Hindu University, Varanasi, India. I received my M.Tech. and Ph.D. degrees in Computer Science and Engineering from Atal Bihari Vajpayee-Indian Institute of Information Technology and Management, Gwalior. Subsequently, I pursued postdoctoral research at Indian Institute of Technology Kharagpur, India. I am currently serving as an Assistant Professor in the Department of Computer Science at Banaras Hindu University (BHU), Varanasi, India, with over 10 years of academic and research experience. Prior to joining BHU, I worked as a faculty member in the Department of Computer Science and Engineering at Motilal Nehru National Institute of Technology, Allahabad and National Institute of Technology, Jamshedpur. My research interests include Cloud Computing, Distributed Systems, Mobile Ad Hoc Networks, and Formal Verification. I have also played an active role in the research community by organizing five editions of the International Conference on Advanced Network Technologies and Intelligent Computing (ANTIC) as General Chair and Convener since 2021. I have authored more than 100 publications in reputed journals, books, and international conferences. In addition, I have successfully completed two externally funded and three institutionally funded research projects as Principal Investigator/Co-Principal Investigator. I actively contribute to the academic publishing ecosystem, serving as Associate Editor of the Journal of Scientific Research of the Banaras Hindu University and as an Editorial Board Member of Scientific Reports published by Springer Nature.

I have published the following works in collaboration with Prof. Buyya and have communicated 6 research articles in reputed journals and conferences.

Anshul Verma, Pradeepika Verma, Kiran Kumar Pattanaik, Rajkumar Buyya, Dipankar Dasgupta (Editors), “Advanced Network Technologies and Intelligent Computing: 4th International Conference, ANTIC 2024, Varanasi, India, December 19–21, 2024, Proceedings, Part-I”, Springer Cham, pages 476, 2025. *ISBN: 978-3-031-83783-8*

Anshul Verma, Pradeepika Verma, Kiran Kumar Pattanaik, Rajkumar Buyya, Dipankar Dasgupta (Editors), “Advanced Network Technologies and Intelligent Computing: 4th International Conference, ANTIC 2024, Varanasi, India, December 19–21, 2024, Proceedings, Part-II”, Springer Cham, pages 476, 2025. *ISBN: 978-3-031-83790-6*

Anshul Verma, Pradeepika Verma, Kiran Kumar Pattanaik, Rajkumar Buyya, Dipankar Dasgupta (Editors), “Advanced Network Technologies and Intelligent Computing: 4th International Conference, ANTIC 2024, Varanasi, India, December 19–21, 2024, Proceedings, Part-III”, Springer Cham, pages 489, 2025. *ISBN: 978-3-031-83793-7*

Anshul Verma, Pradeepika Verma, Kiran Kumar Pattanaik, Rajkumar Buyya, Dipankar Dasgupta (Editors), “Advanced Network Technologies and Intelligent Computing: 4th International Conference, ANTIC 2024, Varanasi, India, December 19–21, 2024, Proceedings, Part-IV”, Springer Cham, pages 378, 2025. *ISBN: 978-3-031-83796-8*

For more information please refer,
My profile: https://www.bhu.ac.in/Site/FacultyProfile/1_8?FA000043
Google Scholar: https://scholar.google.co.in/citations?user=PK_vW7IAAAAJ&hl=en

Research Visitor: Qiqi Cai

I joined the qCLOUDS Lab as a visiting student in October 2025 at the University of Melbourne, working under the supervision of Prof. Rajkumar Buyya. I am currently a PhD student in the School of Computer Science at Shanghai Jiao Tong University, supervised by Prof. Jian Cao.

Before starting my PhD, I received my Bachelor's degree in Computer Science and Technology from Lanzhou University in 2022. My academic background and research training have provided a strong foundation in distributed systems and machine learning.

My research interests include distributed artificial intelligence, federated learning, and machine learning operations. I focus on how distributed computing resources such as cloud, edge, and end devices can collaborate to support efficient training, deployment, and management of machine learning models. My recent work explores federated continual learning, resource aware model training, and distributed recommendation systems.

My recent research publications are as follows.

1. Qiqi Cai, Jian Cao, Guandong Xu, and Nengjun Zhu. Distributed Recommendation Systems: Survey and Research Directions. ACM Transactions on Information Systems (TOIS), accepted.

2. Qiqi Cai, Jian Cao, Yirong Chen, Shiyou Qian, Liangxiao Yuan, and Jie Wang. PREFER: A Pre-trained Model Recommendation Framework for Edge Computing Enabled Traffic Flow Prediction. ACM Transactions on Knowledge Discovery from Data (TKDD), accepted.

3. Qiqi Cai, Jian Cao, Shiyou Qian, Jianqing Zhang, Nengjun Zhu, and Rajkumar Buyya. FedAD: An Adaptive Block Dropping Approach for Federated Learning on Resource-constrained Devices. Submitted to IEEE Transactions on Parallel and Distributed Systems (TPDS), under 2nd review.

4. Qiqi Cai, Jian Cao, Shiyou Qian, Jianqing Zhang, and Nan Zhu. FedMoG: Mixture-of-Experts based Federated Continual Learning with Gaussian Task Recognition. Submitted to the 19th European Conference on Computer Vision (ECCV 2026), under review.

Research Visitor: Chuanxiu Chi

I am currently a visiting student at the University of Melbourne. I received my Bachelor's and Master's degrees from Yantai University between 2015 and 2022, and I am now pursuing my PhD at the Beijing University of Posts and Telecommunications.

My research focuses on the reliability of satellite computing systems. I study the propagation of internal component failures intensified by low-cost COTS devices and tightly integrated architectures, the risks introduced by external environmental threats such as the rapid growth of space debris and complex orbital perturbations, and the acceleration of system aging and failure under heavy onboard workloads. I work on data-driven anomaly analysis and investigate how subsystem faults propagate under complex space conditions.

8. Selected Projects/Programs

Cloudbus: A Toolkit for Market-Oriented Cloud Computing

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

The Quantum 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: Cloudbus and iQuantum.

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 is engaged in the creation of open-source specifications, architecture and a reference toolkit implementation for 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
- InterCloud – Peering and Federation of Clouds
- Software Defined Networks
- Big Data
- Internet of Things (IoT)
- Fog and Edge Computing
- Application Targets include: Deed Learning, ECG Monitoring & Analysis, Data Mining & Business Analytics, and Brain Imaging (Dartmouth Medical School).
- Artificial intelligence (AI) for Next-Gen Cloud Computing
- Quantum Computing

Future Research is Driven By:

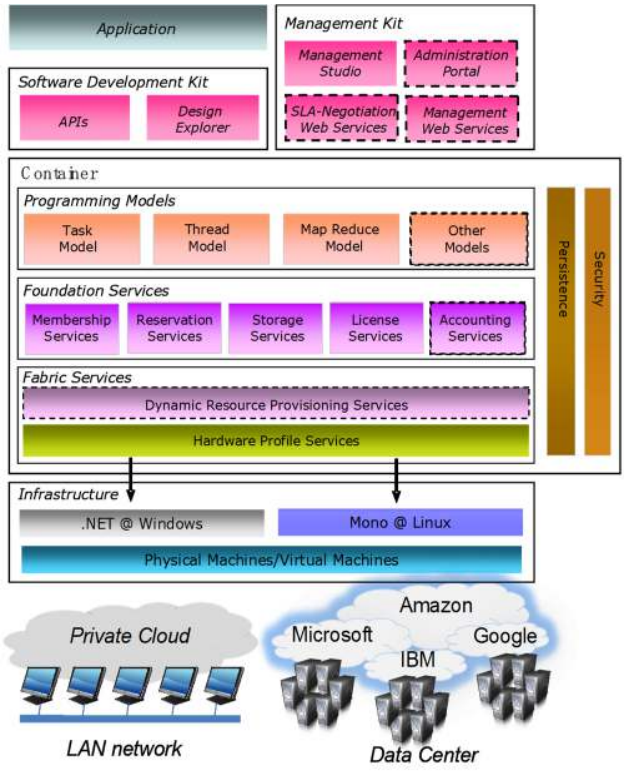
A Manifesto for Future Generation Cloud Computing: Research Directions for the Next Decade,

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 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)
- In 2024, we released Aneka 6.0 edition and updated to the latest .NET framework.



Aneka Architecture

A new edition of book with Aneka examples: Rajkumar Buyya, Christian Vecchiola, Shivananda Poojara, Satish Srirama, and Thamarai Selvi, Mastering Cloud Computing: Powering AI, BigData, and IoT Applications, ISBN: 9355329504, McGraw Hill, New Delhi, India, June 2024.

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.

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.

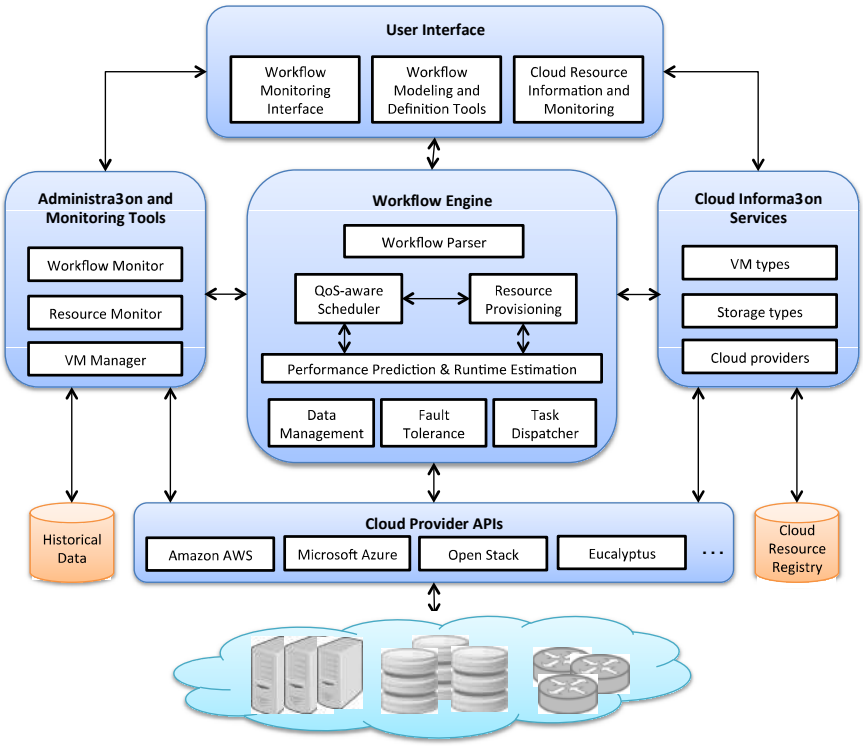


Fig. 1: Architecture of QoS-based workflow management and resource allocation system.

Some References:

- Amanda Jayanetti, Saman Halgamuge, and Rajkumar Buyya, Multi-Agent Deep Reinforcement Learning Framework for Renewable Energy-Aware Workflow Scheduling on Distributed Cloud Data Centers, IEEE Transactions on Parallel and Distributed Systems (TPDS), Volume 35, No. 4, Pages: 604-615, ISSN: 1045-9219, IEEE CS Press, USA, April 2024.
- Muhammad Hilman, Maria Rodriguez, and Rajkumar Buyya, Workflow-as-a-Service Cloud Platform and Deployment of Bioinformatics Workflow Applications, Knowledge Management in Development of Data-Intensive Software Systems, I. Mistrik, M. Galster, B. Maxim, B. Tekinerdogan (eds), 205-228pp, ISBN: 978-1-003-00118-8, CRC Press, USA, June 2021.

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.
- Shashikant Ilager, Kotagiri Ramamohanarao, and Rajkumar Buyya, Thermal Prediction for Efficient Energy Management of Clouds using Machine Learning, IEEE Transactions on Parallel and Distributed Systems (TPDS), Volume 32, No. 5, Pages: 1044-1056, ISSN: 1045-9219, IEEE CS Press, USA, May 2021.
- Shashikant Ilager, Adel N. Toosi, Mayank Raj Jha, Ivona Brandic, Rajkumar Buyya, A Data-driven Analysis of a Cloud Data Center: Statistical Characterization of Workload, Energy and Temperature, Proceedings of the 16th IEEE/ACM International Conference on Utility and Cloud Computing (UCC 2023, IEEE CS Press, USA), Messina, Italy, December 4-7, 2023.
- Rajkumar Buyya, Shashikant Ilager, and Patricia Arroba, Energy-Efficiency and Sustainability in New Generation Cloud Computing: A Vision and Directions for Integrated Management of Data Centre Resources and Workloads, Software: Practice and Experience (SPE), Volume 54, Issue 1, Pages: 24-38, ISSN: 0038-0644, Wiley Press, New York, USA, January 2024.
- Tharindu B. Hewage, Shashikant Ilager, Maria Rodriguez Read, and Rajkumar Buyya, Aging-aware CPU Core Management for Embodied Carbon Amortization in Cloud LLM Inference, Proceedings of the 16th ACM International Conference on Future and Sustainable Energy Systems (E-ENERGY 2025, ACM Press, USA), Rotterdam, Netherlands, June 17-20, 2025.

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.

Since its inception in 2009, CloudSim has become the most widely used framework for modeling and simulation of Cloud computing environments. Thousands of researchers have extended its core functionalities to accommodate the rapid evolution of the Cloud Computing paradigm, from simple machine virtualization to modern serverless platforms, fostering the creation of a rich ecosystem of extensions. A recent release of CloudSim 7G, the biggest re-engineering of the codebase to date. The core architecture has been modernized, slimmed down (more than 13000 lines of code removed!) and refactored to facilitate the integration of multiple CloudSim extensions within the same simulated environment.

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, Volume 41, Number 1, Pages: 23-50, Wiley Press, New York, USA, January 2011.
- Remo Andreoli, Jie Zhao, Tommaso Cucinotta, and Rajkumar Buyya, CloudSim 7G: An Integrated Toolkit for Modeling and Simulation of Future Generation Cloud Computing Environments, Software: Practice and Experience (SPE), Volume 55, Issue 6, Pages: 1041-1058, ISSN: 0038-0644, Wiley Press, New York, USA, June 2025.

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.

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- 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, Volume 47, Issue 9, Pages: 1275-1296, 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 and Rajkumar Buyya, Modelling and Simulation of Fog and Edge Computing Environments using iFogSim Toolkit, Fog and Edge Computing: Principles and Paradigms, R. Buyya and S. Srirama (eds), ISBN: 978-111-95-2498-4, Wiley Press, New York, USA, January 2019.
- Mohammad Goudarzi, Huaming Wu, Marimuthu Palaniswami, and Rajkumar Buyya, An Application Placement Technique for Concurrent IoT Applications in Edge and Fog Computing Environments, IEEE Transactions on Mobile Computing (TMC), Volume 20, Number 4, Pages: 1298-1311, ISSN: 1536-1233, IEEE Computer Society Press, USA, April 2021.
- Redowan Mahmud, Samodha Pallewatta, Mohammad Goudarzi, and Rajkumar Buyya, iFogSim2: An Extended iFogSim Simulator for Mobility, Clustering, and Microservice Management in Edge and Fog Computing Environments, Journal of Systems and Software (JSS), Volume 190, Pages: 1-17, ISSN: 0164-1212, Elsevier Press, Amsterdam, The Netherlands, August 2022.

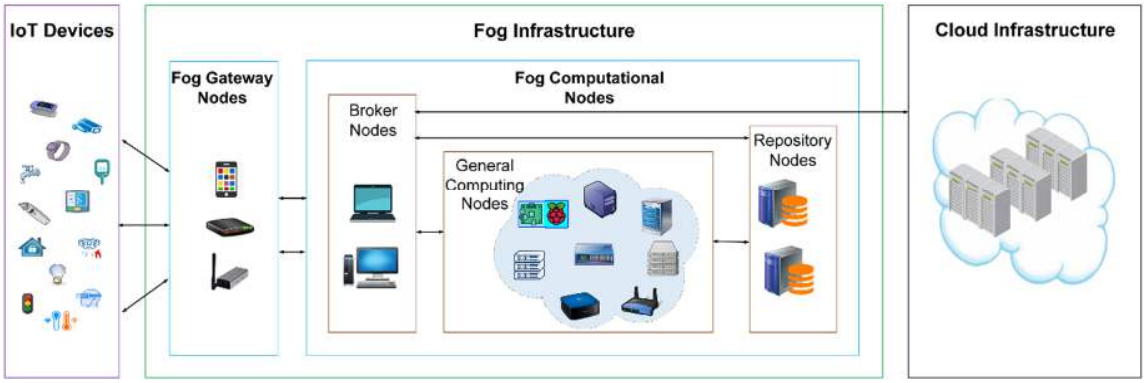
FogBus: A Blockchain-based Lightweight Framework for Edge and Fog Computing

Web: https://github.com/Cloudslab/FogBus

The requirement of supporting both latency sensitive and computing intensive Internet of Things (IoT) applications is increasing the necessity for integrating Edge, Fog and Cloud infrastructures. Since, the integrated environments are distributed, centralized management of its resources is not feasible when latency sensitive data load is very high. Heterogeneity of resources and communication model further obstruct smooth execution of applications in integrated environments. In addition, Security of data and resources is also a very major concern of integrated Fog-Cloud environments. There exist several works implementing software frameworks for integrating IoT-enabled systems, Fog and Cloud infrastructure. They;

- Barely support simultaneous execution of multiple applications and platform independence.
- Offer narrow scope to application developers and users to tune them framework according to individual requirements.
- Apply centralized techniques that eventually increase management time and service delay.
- Considers a few security aspects.

To overcome these problems, we have developed a lightweight framework for integrating IoT devices, Fog Computing and Cloud infrastructures. It offers platform independent application execution and node-to-node interaction overcoming resource heterogeneity. Moreover, it incorporates a Platform-as-a-Service (PaaS) model that assists both application developers and services providers. Based on FogBus, we have also developed a prototype application system for Sleep Apnea analysis in integrated IoT-Fog-Cloud environment. Furthermore, for ensuring data security, FogBus implements Blockchain, encryption and digital signature techniques.



References:

[1] Shreshth Tuli, Redowan Mahmud, Shikhar Tuli, and Rajkumar Buyya, FogBus: A Blockchain-based Lightweight Framework for Edge and Fog Computing, Journal of Systems and Software (JSS), Volume 154, Pages: 22-36, Elsevier Press, Amsterdam, The Netherlands, August 2019.
[2] Shreshth Tuli, Nipam Basumatary, and Rajkumar Buyya, EdgeLens: Deep Learning based Object Detection in Integrated IoT, Fog and Cloud Computing Environments, Proceedings of the 4th IEEE International Conference on Information Systems and Computer Networks (ISCON 2019, IEEE Press, USA), Mathura, India, November 21-22, 2019.
[3] Qifan Deng, Mohammad Goudarzi, Arash Shaghaghi, Majid Sarvi, and Rajkumar Buyya, A Secure Framework for Containerized IoT Applications in Integrated Edge-Cloud Computing Environments, Future Generation Computer Systems (FGCS), Volume 174, Pages: 1-19, ISSN: 0167-739X, Elsevier Press, Amsterdam, The Netherlands, January 2026.

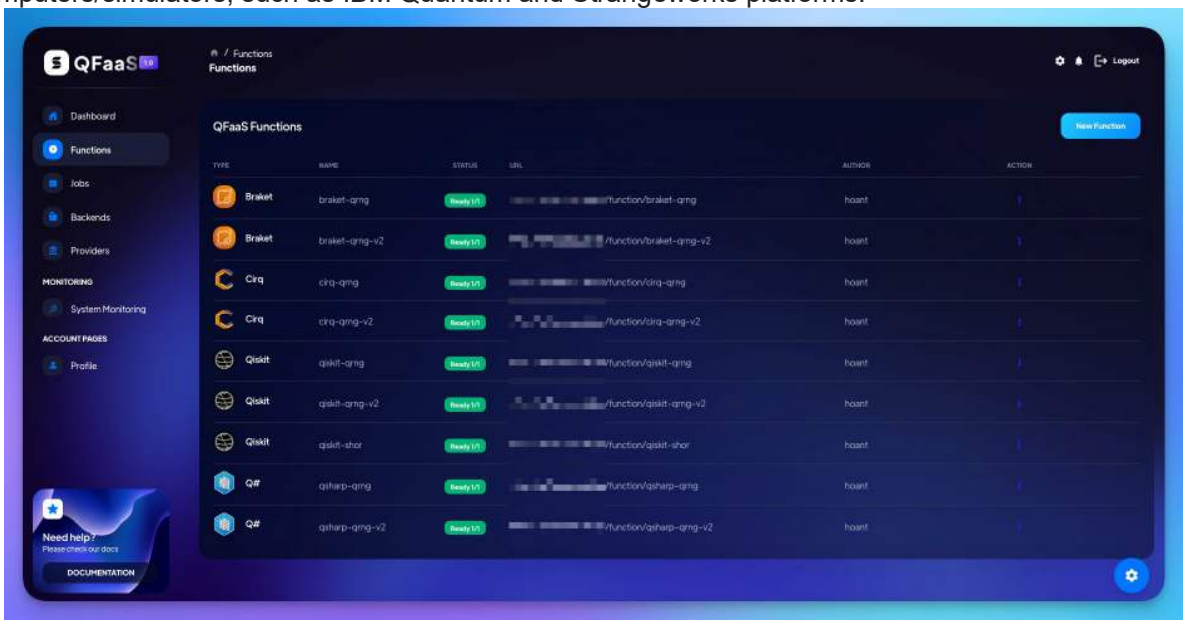
QFaaS - A Serverless Quantum Function-as-a-Service Framework

Project's Github: https://github.com/Cloudslab/qfaas

QFaaS is a Quantum Function-as-a-Service framework that leverages the advantages of the serverless computing model and state-of-the-art software engineering techniques to advance practical quantum computing in the Noisy Intermediate-Scale Quantum (NISQ) era. Our framework provides essential elements of a serverless quantum system to streamline service-oriented quantum application development in cloud environments, such as combining hybrid quantum-classical computation, automating the backend selection, and adapting Quantum DevOps workflow. QFaaS offers the first full-stack and unified quantum serverless platform by integrating multiple well-known quantum software development kits, quantum simulators, and quantum cloud providers (IBM Quantum and Amazon Braket).

Highlights

- A comprehensive and open-source serverless function-as-a-service framework for quantum computing.
- Support developing quantum functions using 4 popular SDKs, including Qiskit, Q#, Cirq, and Braket.
- Built-in APIs with API gateway to manage system components, quantum functions, jobs, quantum backend and providers.
- Simplify quantum programming and enable hybrid quantum-classical function development.
- Execute quantum functions on both internal quantum simulators and external quantum computers/simulators, such as IBM Quantum and Strangeworks platforms.



Reference

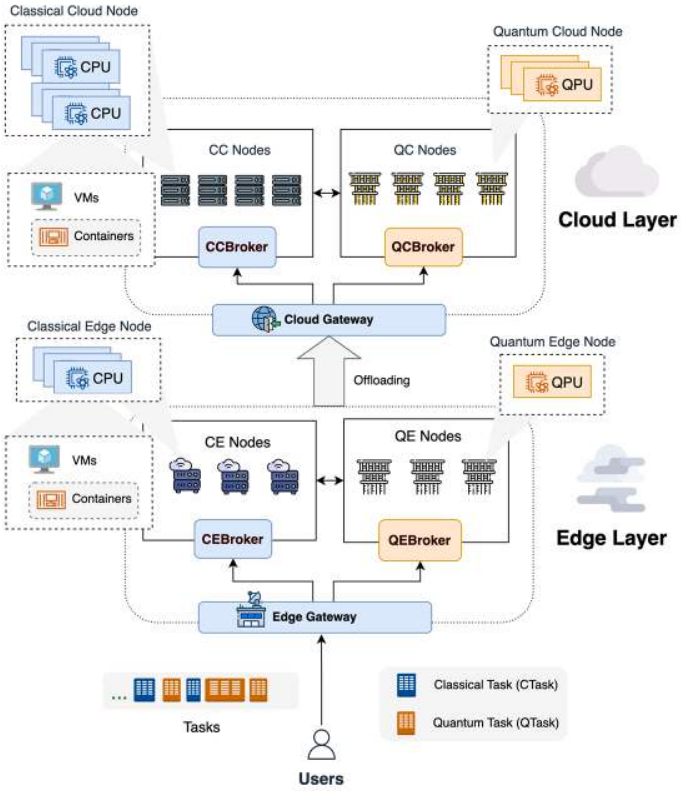
[1] Hoa T. Nguyen, Muhammad Usman, and Rajkumar Buyya, "*QFaaS: A Serverless Function-as-a-Service framework for Quantum computing*," Future Generation Computer Systems, vol. 154. Elsevier BV, pp. 281–300, May 2024. doi: 10.1016/j.future.2024.01.018

[2] Hoa T. Nguyen, Bui Binh An Pham, Muhammad Usman, and Rajkumar Buyya, Quantum Serverless Paradigm and Application Development Using the QFaaS Framework, Quantum Computing: Principles and Paradigms, 139-164pp, R. Buyya and S. Gill (eds), ISBN: 978-0-443-29096-1, Morgan Kaufmann Press, Cambridge, MA 02139, USA, July 2025.

iQuantum - A Toolkit for Modeling and Simulation of Quantum Computing Environments

- **Project's Github**: https://github.com/Cloudslab/iQuantum

As quantum computers become increasingly accessible through cloud services and potentially extend to edge networks in the future, the demand for efficient resource management strategies is paramount to ensure the efficient utilization of quantum computing resources. However, the limitations of employing practical quantum computing resources and the lack of quantum environment modeling toolkits have hindered the design and evaluation of quantum resource management policies. To address this challenge, we propose iQuantum, a lightweight and versatile discrete-event modeling and simulation toolkit (based on CloudSim) for quantum computing environments. iQuantum provides a set of quantum computing entities that can be customized and extended to support a wide range of different hybrid quantum computing environments, supporting research in quantum resource management (e.g., task scheduling, backend selection, hybrid task orchestration), designing and prototyping of quantum computing systems.



Highlights

- Modeling quantum computing entities: QDatacenters, QNode, QPU, QTask, and QBroker.
- Modeling and simulation of quantum resource management, task scheduling, and backend selection policies for quantum computing environments.
- Modeling Hybrid Quantum-Classical Task Orchestration and Offloading in the Cloud-Edge Continuum.
- Importing quantum nodes and workload dataset (from calibration data and QASM files) and exporting simulation results.

Reference

[1] Hoa T. Nguyen, Muhammad Usman, and Rajkumar Buyya, *"iQuantum: A Case for Modeling and Simulation of Quantum Computing Environments," 2023 IEEE International Conference on Quantum Software (QSW)*, Chicago, IL, USA, 2023, pp. 21-30, doi: 10.1109/QSW59989.2023.00013.

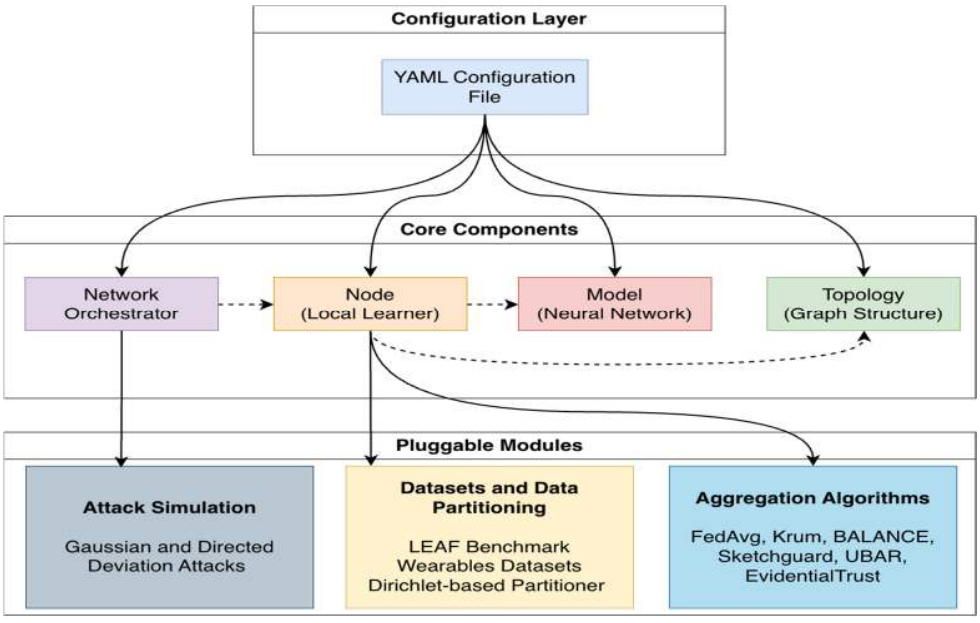
[2] Hoa T. Nguyen, Muhammad Usman, and Rajkumar Buyya, *"iQuantum: A Toolkit for Modeling and Simulation of Quantum Computing Environments"*, Journal of Software: Practice and Experience, Wiley, 2024.

MURMURA – A Modular Framework for Decentralized Federated Learning Research

Project Repository: https://github.com/Cloudslab/murmura

Decentralized Federated Learning (DFL) enables collaborative model training across distributed nodes without a central server. Evaluating and comparing DFL algorithms is, however, difficult in practice: topology choices, data partitioning strategies, and heterogeneity levels all interact with algorithmic design, yet most existing implementations conflate these concerns or evaluate on fixed, hard-coded settings. This makes it hard to isolate the true contribution of a proposed algorithm, reproduce prior results, or systematically study performance across conditions.

MURMURA is a modular, open-source DFL experimentation framework for reproducible research under statistical heterogeneity. It decouples aggregation logic from network topology, supports pluggable algorithms (such as FedAvg, Krum, Sketchguard, etc), configurable topologies, and both synthetic and natural data partitioning, all specified via YAML for exact reproduction and automated parameter sweeps.



Within the framework, we introduce **EvidentialTrust**: a trust-aware personalisation algorithm using Evidential Deep Learning to assess peer compatibility. Nodes evaluate peer models on local data where high epistemic uncertainty signals distributional mismatch, enabling selective aggregation without central coordination.

References

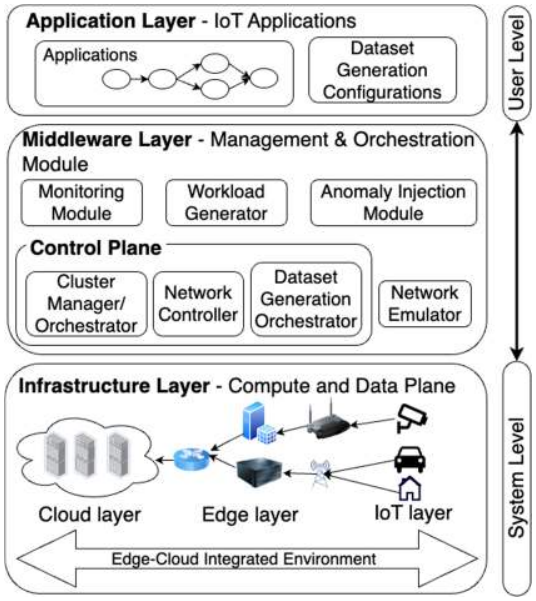
[1] M. Rangwala, R. O. Sinnott, and R. Buyya, "Evidential Trust-Aware Model Personalization in Decentralized Federated Learning for Wearable IoT," arXiv preprint arXiv:2512.19131, 2025. *(To appear in proceedings of the 26th IEEE International Symposium on Cluster, Cloud and Internet Computing, CCGrid 2026)*

iAnomaly: A Toolkit for Generating Performance Anomaly Datasets in Edge-Cloud Integrated Computing Environments

Project's Github: https://github.com/Cloudslab/iAnomaly

iAnomaly is a full-system emulator equipped with open-source tools and fully automated dataset generation capabilities to generate labeled normal and anomaly data based on user-defined configurations.
It comprises of

- A full-system emulator
  - Equipped with the following open-source tools
    - Monitoring tool: Collects performance and system-level metrics.
    - Workload generation tool: Generates normal performance data.
    - Chaos engineering mechanism: Injects performance anomalies into applications to simulate anomalous scenarios.
  - Supporting fully automated dataset generation capabilities to generate labelled normal (data collected under normal conditions without anomalies) and anomaly (data collected under anomalous conditions) data based on user-defined configurations.
  - Having the ability to introduce a wide variety of anomalies including those originating on the client/sensor-side as well as the server-side.
- The source code for a set of microservice-based IoT applications with heterogeneous QoS and resource requirements spanning across a wide range of domains, software architectures, service composition patterns, and communication protocols, making the toolkit versatile for generating data.
- The first open-source edge performance anomaly dataset generated using the iAnomaly toolkit.



Reference

[1] D. Fernando, M. A. Rodriguez and R. Buyya, "iAnomaly: A Toolkit for Generating Performance Anomaly Datasets in Edge-Cloud Integrated Computing Environments," 2024 IEEE/ACM 17th International Conference on Utility and Cloud Computing (UCC), Sharjah, United Arab Emirates, 2024.

9. Moments with Visitors, Colleagues and International Hosts

FINDS: U.S. Army Funded Digital Forensics Center of Excellence Conference, Miami, Florida, USA, May 6, 2025.

A snap at Quantum Computing Centre @ Rensselaer Polytechnic Institute, May 2025.

New Jersey Institute of Technology (Prof. MENGCHU ZHOU and Prof. David A. Bader)

The 25th IEEE International Symposium on Cluster, Cloud, and Internet Computing (CCGrid 2025), Tromso, Norway, May 19-22, 2025.

PES University, Bangalore, Aug 2025.

A Group Photo

35th International Telecommunication Network and Applications Conference (ITNAC 2025, IEEE Press, USA), Christchurch, New Zealand, November 26-28, 2025.

3rd International Conference on Advanced Computing, Machine Learning, Robotics and Internet Technologies (AMRIT-2025), Assam University, Silchar/Diphu Campus, December 22-24, 2025.