21st IEEE/ACM International Symposium on Cluster, Cloud and Internet Computing

CCGrid 2021

21st IEEE/ACM International Symposium on Cluster, Cloud and Internet Computing

CCGrid 2021

10–13 May 2021 Melbourne, Australia

Editors

Laurent Lefevre Stacy Patterson Young Choon Lee Haiying Shen Shashikant Ilager Mohammad Goudarzi Adel N. Toosi Rajkumar Buyya



Los Alamitos, California Washington • Tokyo



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Table of Contents

Message from the General Chair	xix
Message from the Program Chair	xxii
Organizing Chairs	xxiv
Organizing Committee	xxvi
Program Committee	xxvii

CCGrid 2021 Main Conference

Session 1: Internet Computing Frontiers

Living on the Edge: Efficient Handling of Large Scale Sensor Data Roman Karlstetter (IfTA GmbH, Technical University of Munich, Germany), Amir Raoofy (Technical University of Munich, Germany), Martin Radev (Technical University of Munich, Germany), Carsten Trinitis (Technical University of Munich, Germany), Jakob Hermann (IfTA GmbH, Germany), and Martin Schulz (Technical University of Munich, Germany)	1
Learning Early Exit for Deep Neural Network Inference on Mobile Devices through Multi-armed Bandits	11
IoT Data Placement in the Fog Infrastructure with Mobile Devices	21

Session 2: Storage and I/O Systems

Competition-Based Adaptive Caching for Out-of-Core Graph Processing Kihyeon Myung (Seoul National University; Samsung Electronics), Hwajung Kim (Seoul National University), Yunjae Lee (Seoul National University), and HeonYoung Yeom (Seoul National University)	31
Compression of Time Evolutionary Image Data through Predictive Deep Neural Networks Rupak Roy (Florida State University), Kento Sato (RIKEN Center for Computational Science (R-CCS)), Subhadeep Bhattacharya (Florida State University), Xingang Fang (Florida State University), Yasumasa Joti (RIKEN SPring-8 Center), Takaki Hatsui (RIKEN SPring-8 Center), Toshiyuki Nishiyama Hiraki (RIKEN SPring-8 Center), Jian Guo (Anhui University of Finance and Economics), and Weikuan Yu (Florida State University)	41
Battle of the Defaults: Extracting Performance Characteristics of HDF5 Under Production Load Bing Xie (Oak Ridge National Laboratory), Houjun Tang (Lawrence Berkeley National Laboratory), Suren Byna (Lawrence Berkeley National Laboratory), Jesse Hanley (Oak Ridge National Laboratory), Quincey Koziol (Lawrence Berkeley National Laboratory), Tonglin Li (Lawrence Berkeley National Laboratory), and Sarp Oral (Oak Ridge National Laboratory)	51
FlashByte: Improving Memory Efficiency with Lightweight Native Storage Junxian Zhao (University of Colorado, USA), Aidi Pi (University of Colorado, USA), Shaoqi Wang (University of Colorado, USA), and Xiaobo Zhou (University of Colorado, USA)	61
FSSort: External Sort for Solid State Drives Yubiao Chen (Harbin Institute of Technology, China), Jianzhong Li (Harbin Institute of Technology, China), and Hong Gao (Harbin Institute of Technology, China)	71
DLIO: A Data-Centric Benchmark for Scientific Deep Learning Applications Hariharan Devarajan (Illinois Institute of Technology, Chicago), Huihuo Zheng (Argonne National Laboratory), Anthony Kougkas (Illinois Institute of Technology, Chicago), Xian-He Sun (Illinois Institute of Technology, Chicago), and Venkatram Vishwanath (Argonne National Laboratory)	81
Mind the Gap: Generating Imputations for Satellite Data Collections at Myriad Spatiotemporal Scopes Paahuni Khandelwal (Colorado State University, Fort Collins, Colorado), Daniel Rammer (Colorado State University, Fort Collins, Colorado), Shrideep Pallickara (Colorado State University, Fort Collins, Colorado), and Sangmi Lee Pallickara (Colorado State University, Fort Collins, Colorado)	92

Session 3: Programming Models and Runtime Systems

Co-Designing Multi-Level Checkpoint Restart for MPI Applications Konstantinos Parasyris (Lawrence Livermore National Laboratory), Giorgis Georgakoudis (Lawrence Livermore National Laboratory), Leonardo Bautista-Gomez (Barcelona Supercomputing Center), and Ignacio Laguna (Lawrence Livermore National Laboratory)	103
Adaptive and Hierarchical Large Message All-to-All Communication Algorithms for Large-Scale Dense GPU Systems	113
Shared-Memory Communication for Containerized Workflows Tanner Hobson (University of Tennessee, Knoxville, USA), Orcun Yildiz (Argonne National Laboratory, Mathematics and Computer Science, USA), Bogdan Nicolae (Argonne National Laboratory, Mathematics and Computer Science, USA), Jian Huang (University of Tennessee, Knoxville, USA), and Tom Peterka (Argonne National Laboratory, Mathematics and Computer Science, USA)	123
TiAcc: Triangle-Inequality Based Hardware Accelerator for K-Means on FPGAs Yuke Wang (University of California, Santa Barbara), Boyuan Feng (University of California, Santa Barbara), Gushu Li (University of California, Santa Barbara), Georgios Tzimpragos (University of California, Santa Barbara), Lei Deng (University of California, Santa Barbara), Yuan Xie (University of California, Santa Barbara), and Yufei Ding (University of California, Santa Barbara)	133
RMACXX: An Efficient High-Level C++ Interface over MPI-3 RMA Sayan Ghosh (Pacific Northwest National Laboratory, USA), Yanfei Guo (Argonne National Laboratory, USA), Pavan Balaji (Facebook, Inc, USA), and Assefaw H. Gebremedhin (Washington State University, USA)	143
Quantum Annealing for ICT System Design Automation Takayuki Kuroda (NEC Corporation, Japan), Takuya Kuwahara (NEC Corporation, Japan), Takao Osaki (NEC Corporation, Japan), Kouki Yonaga (Sigma-i Co., Ltd., Japan; Graduate School of Information Sciences, Tohoku University, Japan; MathAM-OIL, AIST, Japan), Masamichi J. Miyama (Sigma-i Co., Ltd., Japan; Graduate School of Information Sciences, Tohoku University, Japan), and Masayuki Ohzeki (Sigma-i Co., Ltd., Japan; Graduate School of Information Sciences, Tohoku University, Japan; Institute of Innovative Research, Tokyo Institute of Technology, Japan)	156
DVQShare: An Analytics System for DNN-Based Video Queries Hao Fu (Tianjin University, China), Shanjiang Tang (Tianjin University, China), Ce Yu (Tianjin University, China), Yusen Li (Nankai University, China), Jizhou Sun (Tianjin University, China), and Yanjie Liu (Tianjin University, China)	166

Session 4: Resource Management and Scheduling

 Perph: A Workload Co-Location Agent with Online Performance Prediction and Resource Inference
Rakshita Kaulgud Ramesh (University of Virginia, USA), Haoyu Wang (University of Virginia, USA), Haiying Shen (University of Virginia, USA), and Zhiming Fan (University of Virginia, USA)
A Simulator for Intelligent Workload Managers in Heterogeneous Clusters
Data-Driven Scheduling in Serverless Computing to Reduce Response Time
 Straggler-Aware Parallel Graph Processing in Hybrid Memory Systems
CASH: A Credit Aware Scheduling for Public Cloud Platforms
 IMITA: Imitation Learning for Generalizing Cloud Orchestration

Comparing SARS-CoV-2 Sequences using a Commercial Cloud with a Spot Instance Based Dynamic Scheduler
Brazil), Alan L. Nunes (Institute of Computing, Federal Fluminense University, Brazil), Alba C. M. A. Melo (University of Brasilia, Brazil), Cristina Boeres (Institute of Computing, Fluminense Federal University, Brazil), Lúcia Maria de A. Drummond (Institute of Computing, Fluminense Federal University, Brazil), and Natalia F.
Martins (Embrapa Genetic Resources and Biotechnology, Brazilian Agricultural Research Corporation, Brazil)
Fuzzy-Engineered Multi-Cloud Resource Brokering for Data-Intensive Applications
User-Centric Design and Evolvable Architecture for Science Gateways: A Case Study

Session 5: Performance Modelling and Evaluation

Efficient MPI-Based Communication for GPU-Accelerated Dask Applications	77
Characterizing Input-Sensitivity in Tightly-Coupled Collaborative Graph Algorithms	37
Deep Reinforcement Learning for Collaborative Offloading in Heterogeneous Edge Networks 29 Dinh C. Nguyen (Deakin University, Australia), Pubudu N. Pathirana (Deakin University, Australia), Ming Ding (Data61, CSIRO, Australia), and Aruna Seneviratne (UNSW, Australia))7
Profile-Guided Frequency Scaling for Latency-Critical Search Workloads)4

MEAD: Model-Based Vertical Auto-Scaling for Data Stream Processing	314
Gabriele Russo Russo (University of Rome Tor Vergata, Italy), Valeria	
Cardellini (University of Rome Tor Vergata, Italy), Giuliano Casale	
(Imperial College London, UK), and Francesco Lo Presti (University of	
Rome Tor Vergata, Italy)	
SelfWatts: On-the-fly Selection of Performance Events to Optimize Software-Defined Power	
Meters	324
Guillaume Fieni (Univ. Lille / Inria), Romain Rouvoy (Univ. Lille /	

Session 6: Cyber-Security and Privacy

Inria / IUF), and Lionel Seinturier (Univ. Lille / Inria)

PriPro: Towards Effective Privacy Protection on Edge-Cloud System Running DNN Inference 33 Ruiyuan Gao (Beihang University, China; The Chinese University of Hong Kong, China), Hailong Yang (Beihang University, China), Shaohan Huang (Beihang University, China; Microsoft Research Asia, China), Ming Dun (Beihang University, China), Mingzhen Li (Beihang University, China), Zerong Luan (Beijing University of Technology, China), Zhongzhi Luan (Beihang University, China), and Depei Qian (Beihang University, China)	34
Efficient DLP-Visor: An Efficient Hypervisor-Based DLP	44
ZSS Signature Based Data Integrity Verification for Mobile Edge Computing	56
SAED: Edge-Based Intelligence for Privacy-Preserving Enterprise Search on the Cloud	56

Session 7: Applications

Truong Thao Nguyen (AIST-Tokyo Tech Real World Big-Data Computation Open Innovation Laboratory (RWBC-OIL), Japan) and Mohamed Wahib (AIST-Tokyo Tech Real World Big-Data Computation Open Innovation Laboratory (RWBC-OIL), Japan; RIKEN-CCS, Japan)

Session 8: Architecture, Networking, Data Centers & Performance Modelling and Evaluation

T-Rank:A Lightweight Spectrum Based Fault Localization Approach for Microservice Systems . 416 Zihao Ye (Sun Yat-sen University, China), Pengfei Chen (Sun Yat-sen University, China), and Guangba Yu (Sun Yat-Sen University, China)

Session 9: Internet Computing Frontiers & Resource Management and Scheduling

OpenDC 2.0: Convenient Modeling and Simulation of Emerging Technologies in Cloud Datacenters
Fabian Mastenbroek (TU Delft; VU Amsterdam), Georgios Andreadis (Solvinity, the Netherlands; TU Delft; VU Amsterdam), Soufiane Jounaid (VU Amsterdam), Wenchen Lai (VU Amsterdam), Jacob Burley (VU Amsterdam), Jaro Bosch (VU Amsterdam), Erwin van Eyk (VU Amsterdam), Laurens Versluis (VU Amsterdam), Vincent van Beek (Solvinity, the Netherlands; VU Amsterdam), and Alexandru Iosup (VU Amsterdam; TU Delft)
Scheduling Containers Rather Than Functions for Function-as-a-Service
Joint Network Selection and Task Offloading in Mobile Edge Computing
Deadline-Aware Dynamic Resource Management in Serverless Computing Environments 483 Anupama Mampage (Cloud Computing and Distributed Systems (CLOUDS) Laboratory, School of Computing and Information Systems, The University of Melbourne, Australia), Shanika Karunasekera (Cloud Computing and Distributed Systems (CLOUDS) Laboratory, School of Computing and Information Systems, The University of Melbourne, Australia), and Rajkumar Buyya (Cloud Computing and Distributed Systems (CLOUDS) Laboratory, School of Computing and Information Systems, The University of Melbourne, Australia)
EFFECT: Energy-Efficient Fog Computing Framework for Real-Time Video Processing
Resilient Stream Processing in Edge Computing
A Two-Sided Matching Model for Data Stream Processing in the Cloud - Fog Continuum514 Narges Mehran (Institute of Information Technology, Alpen-Adria-Universität Klagenfurt, Austria), Dragi Kimovski (Institute of Information Technology, Alpen-Adria-Universität Klagenfurt, Austria), and Radu Prodan (Institute of Information Technology, Alpen-Adria-Universität Klagenfurt, Austria)

Session 10: Applications & Internet Computing Frontiers

TreeNet: A Hierarchical Deep Learning Model to Facilitate Edge Intelligence for	
Resource-Constrained Devices	525
Dong Lu (Beijing Institute of Technology, China), Yanlong Zhai	
(Beijing Institute of Technology, China), Jianqing Wu (University of	
Wollongong, Australia), and Jun Shen (University of Wollongong,	
Australia	

Automating Conflict Detection and Mitigation in Large-Scale IoT Systems Pavana Pradeep (Computer and Information Sciences, Temple University, Philadelphia, USA), Amitangshu Pal (Computer and Information Sciences, Temple University, Philadelphia, USA), and Krishna Kant (Computer and Information Sciences, Temple University, Philadelphia, USA)	535
Fused DSConv: Optimizing Sparse CNN Inference for Execution on Edge D Jia Guo (Ohio State University, Columbus), Radu Teodorescu (Ohio State University, Columbus), and Gagan Agrawal (Augusta University, Augusta)	evices 545
 Al-Oriented Workload Allocation for Cloud-Edge Computing	

Session 11: Architecture, Networking, Data Centers & Internet Computing Frontiers

Edge (of the Earth) Replication: Optimizing Content Delivery in Large LEO Satellite Communication Networks Tobias Pfandzelter (Technische Universität Berlin & Einstein Center Digital Future, Mobile Cloud Computing Research Group) and David Bermbach (Technische Universität Berlin & Einstein Center Digital Future, Mobile Cloud Computing Research Group)	565
A Holistic System Software Integration of Disaggregated Memory for Next-Generation Cloud Infrastructures Panos Koutsovasilis (IBM Research Europe, Ireland), Michele Gazzetti (IBM Research Europe, Ireland), and Christian Pinto (IBM Research Europe, Ireland)	576
WSGP: A Window-Based Streaming Graph Partitioning Approach Yunbo Li (Shanghai Pudong Development Bank, China), Chuanyou Li (Southeast University, China), Anne-Cécile Orgerie (Univ Rennes, Inria, CNRS, IRISA, Rennes, France), and Philippe Raipin Parvédy (Orange Labs, France)	586

Forecasting Operation Metrics for Virtualized Network Functions	596
Tommaso Cucinotta (Scuola Superiore Sant'Anna, Italy), Giacomo	
Lanciano (Scuola Normale Superiore, Italy; Scuola Superiore Sant'Anna,	
Italy), Antonio Ritacco (Scuola Superiore Sant'Anna, Italy), Fabio	
Brau (Scuola Superiore Sant'Anna, Italy), Filippo Galli (Scuola	
Normale Superiore, Italy; Scuola Superiore Sant'Anna, Italy), Vincenzo	
Iannino (Scuola Superiore Sant'Anna, Italy), Marco Vannucci (Scuola	
Superiore Sant'Anna, Italy), Antonino Artale (Vodafone, Italy), Joao	
Barata (Vodafone, Portugal), and Enrica Sposato (Vodafone, Italy)	

Posters

LIMOCE: Live Migration of Containers in the Edge
 Edge4Emotion: An Edge Computing Based Multi-source Emotion Recognition Platform for Human-Centric Software Engineering
Towards Straggler-Tolerant and Accuracy-Aware Distributed DNN Training in Clouds
AMAS: Adaptive Auto-Scaling on the Edge
A Blockchain-Aided Self-Sovereign Identity Framework for Edge-Based UAV Delivery System 622 Chengzu Dong (Deakin University, Australia), Frank Jiang (Deakin University, Australia), Xuejun Li (Anhui University, China), Aiting Yao (Anhui University, China), Gang Li (Deakin University, Australia), and Xiao Liu (Deakin University, Australia)

CCGRID 2021 Workshops

Cloud2Things

IoTwins: Design and Implementation of a Platform for the Management of Digital Twins in	
Industrial Scenarios	. 625
Andrea Borghesi (DISI, University of Bologna), Giuseppe Di Modica	
(DISI, University of Bologna), Paolo Bellavista (DISI, University of	
Bologna), Varun Gowtham (Fraunhofer FOKUS / TU Berlin), Álexander	
Willner (Fraunhofer FOKUS`/ TU Berlin), Daniel Nehls (Fraunhofer FOKUS	
/ TU Berlin), Florian Kintzler (Siemens ÂG, Austria, Vienna), Stephan	
Cejka (Siemens AG, Austria, Vienna), Simone Rossi Tisbeni (INFN-CNAF,	
Bologna), Alessandro Costantini (IŃFN-CNAF, Bologna), Màtteo Galletti	
(INFŇ-CŃAF, Bologna), Marica Antonacci (INFN, Bari), and Iean	
Christian Ahouangonou (ESI Group, Rungis)	

Towards a Cognitive Compute Continuum: An Architecture for Ad-Hoc Self-Managed Swarms 634	
Ana Juan Ferrer (Universitat Oberta de Catalunya, Spain), Sören Becker (Technische Universität Berlin, Germany), Florian Schmidt (Technische Universität Berlin, Germany), Lauritz Thamsen (Technische Universität Berlin, Germany), and Odej Kao (Technische Universität Berlin, Germany)	
OCE-DNS: an Innovative Osmotic Computing Enabled Domain Name System	<u>'</u>
ECO: Edge-Cloud Optimization of 5G Applications)
 Virtual Device Model Extending NGSI-LD for FaaS at the Edge)
From Things into Clouds - and Back	
IOTier: A Virtual Testbed to Evaluate Systems for IoT Environments)

Distribution of Updates to IoT Nodes in a Resource-Challenged Environment	4
 VeerEdge: Towards an Edge-Centric IoT Gateway	0
IWoSeMC 2021 Workshop	
Security Aspects in Blockchain-Based Scheduling in Mobile Multi-cloud Computing	6
Benchmarking Serverless Workloads on Kubernetes	4
Security-Aware job Allocation in Mobile Cloud Computing	3
 Real-Time Scheduling in Drop Computing	0
 Autoencoder-Based IDS for Cloud and Mobile Devices	8

SloTec 2021 Workshop

Software Defined Ambit of Data Integrity for the Internet of Things	7
Trusted Ecosystem for IoT Service Provisioning Based on Brokering	5
Secure Asset Tracking in Manufacturing through Employing IOTA Distributed Ledger Technology	1
³ rivacy-Aware and Context-Sensitive Access Control for Opportunistic Data Sharing	2
 R-GD-RNS: Enhanced Privacy-Preserving Logistic Regression Algorithms for Secure Deployment in Untrusted Environments)
Smart Contract Based Distributed IoT Security: A Protocol for Autonomous Device Management 776 John Wickström (Arcada Univesity of Applied Sciences, Finland), Magnus Westerlund (Arcada Univesity of Applied Sciences, Finland), and Göran Pulkkis (Arcada Univesity of Applied Sciences, Finland)	
STEERS 2021 WORKShop	
Algorithms for Scheduling Scientific Workflows on Serverless Architecture	2
High Performance Serverless Architecture for Deep Learning Workflows)

xvii

A Reinforcement Learning Approach to Reduce Serverless Function Cold Start Frequency Siddharth Agarwal (Cloud Computing and Distributed Systems(CLOUDS) Laboratory, School of Computing and Information Systems, The University of Melbourne, Australia), Maria A. Rodriguez (Cloud Computing and Distributed Systems(CLOUDS) Laboratory, School of Computing and Information Systems, The University of Melbourne, Australia), and Rajkumar Buyya (Cloud Computing and Distributed Systems(CLOUDS) Laboratory, School of Computing and Information Systems, The University of Melbourne, Australia)	. 797
Al-Based Resource Allocation: Reinforcement Learning for Adaptive Auto-Scaling in Serverless Environments Lucia Schuler (Karlsruhe Institute of Technology), Somaya Jamil (IBM Research & Development GmbH), and Niklas Kühl (Karlsruhe Institute of Technology)	804
QoS Aware FaaS Platform Sheshadri K R (Indian Institute of Science, India) and J Lakshmi (Indian Institute of Science, India)	. 812

NEAC 2021 Workshop

SNR: Network-Aware Geo-Distributed Stream Analytics Habib Mostafaei (TU Berlin), Shafi Afridi (TU Berlin), and Jemal H. Abawajy (Deakin University)	. 820
Partially Encrypted Multi-party Computation for Federated Learning Ekanut Sotthiwat (National University of Singapore, Singapore), Liangli Zhen (Institute of High Performance Computing, A*STAR, Singapore), Zengxiang Li (ENNEW Digital Research Institute, ENN Group, China), and Chi Zhang (Institute of High Performance Computing, A*STAR, Singapore)	828

Author Index		
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Message from the General Chair

I am delighted to Chair and host the 21st IEEE/ACM International Symposium on Cluster, Cloud, and Internet Computing (CCGrid 2021) sponsored by the IEEE Computer Society, IEEE Technical Committee on Scalable Computing (TCSC), and the Association for Computing Machinery (ACM) in Melbourne, Australia.

Tremendous advances in network-driven computing, communication, storage, and systems/middleware technologies are leading to new paradigms and platforms, ranging from computing clusters to widely distributed Clouds and emerging Internet computing paradigms such as Fog/Edge Computing for the Internet of Things (IoT) and Big Data applications. CCGrid is a series of very successful conference with the overarching goal of bringing together international researchers, developers, practitioners, and users and to provide an international forum to present leading research activities and results on a broad range of topics related to these platforms and paradigms and their applications. The conference features keynotes, technical presentations, posters, workshops, tutorials, as well as the SCALE challenge featuring live demonstrations and the ICFEC 2021 conference.

CCGrid is an important conference for the international community as it provides a forum for all Cluster, Cloud, and Internet computing researchers, developers, and users, and those who are just curious to learn about advances made in these areas both from technological and applications perspective. The inaugural CCGrid conference was held in Brisbane, Australia in 2001. Since then, the conference has successfully been hosted around the world and has emerged as a truly global event. From 2002 to 2019, CCGrid annual events were held in Germany, Japan, the USA, UK, Singapore, Brazil, France, China, Australia, USA, Canada, Colombia, Spain, USA, and Cyprus. Returning to its originating country, we were honoured to host the 20th anniversary of the CCGrid conference in Melbourne, Australia. But the COVID-19 pandemic worldwide changed some dynamics, which led to hosting of combined 2020 and 2021 program virtually:

The safety and well-being of all conference participants is our priority. After evaluating the COVID-19 pandemic situation worldwide, the conference leadership decided to postpone the physical meeting of CCGrid 2020 to 2021 (May). However, to disseminate research results in timely manner, we published all CCGrid 2020 accepted papers in the Proceedings as per the original date. As this COVID-19 situation still continued in 2021, we decided to hold combined CCGrid 2020 and 2021 events virtually! We will be publishing online videos of all papers (offline/recorded presentations) and keynote/best paper talks (live presented), all these videos will be publicly available through a YouTube channel.

CCGrid has been featuring original and outstanding research work in Cluster, Cloud, and Internet Computing. In fact, many emerging research trends and associated publications are featured "first" in CCGrid and their follow-up papers have appeared in other conferences later. This demonstrates the emergence of CCGrid as a "first" class venue for presenting original and ground-breaking works. For instance, CCGrid has been featuring various Internet computing paradigms actively during the last few years. At the same time, submissions for the Grid computing area have drastically declined. Hence, from 2020, we explicitly recognized this growing

trend in CCGrid by including "Internet computing" in the conference title to embrace all emerging/new Internet-driven computing paradigms including Edge and Fog computing. CCGrid 2021 conference offers an outstanding technical program featuring keynote talks, workshops, mini-symposiums, posters sessions, industry track, and IEEE SCALE competition. CCGrid has been extremely fortunate to serve as a venue for presentation of prestigious "IEEE Medal/Award for Excellence in Scalable Computing" award offered annually by the IEEE Technical Committee on Scalable Computing. We are fortunate to host three keynote speakers from Australia, USA, and Europe. Our Australian-originated keynote speaker, Professor John Grundy, is a Laureate Fellowship recipient from Australian Research Council. American and European keynote speakers are: Professor Wu Feng from Virginia Polytechnic Institute and State University, USA and Professor Schahram Dustdar from Vienna University of Technology (TU Wien), Austria.

The continued success and leadership of CCGrid requires dedicated and high-quality efforts from several international leaders and volunteers. As the Chair of CCGrid conference series and General Chair of this year's event, I would like to express my sincere gratitude to the members of the Steering Committee, General Co-Chair Professor Gul Agha (University of Illinois at Urbana-Champaign, USA) and the Program Committee co-chairs Professor Laurent Lefevre (Inria, ENS Lyon, France), Professor Stacy Patterson (Rensselaer Polytechnic Institute, USA) and Professor Young Choon Lee (Macquarie University, Australia). The Program Committee Co-Chairs and Vice chairs have coordinated peer-reviews of all submitted "full" papers and selected top-quality research papers for presentation at the conference. The CCGrid 2021 conference received 230 submissions (full papers) from 812 co-authors from 47 countries/autonomous regions around the world including: Argentina, Australia, Austria, Brazil, Canada, China, Cyprus, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Indonesia, Ireland, Israel, Italy, Japan, Luxembourg, Macao, Malaysia, Morocco, Netherlands, New Zealand, Norway, Pakistan, Poland, Portugal, Puerto Rico, Romania, Russia, Saudi Arabia, Senegal, Serbia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Tunisia, United Kingdom, and United States of America. After peer-review of all submitted "full" papers, the Program Committee accepted 60 papers, resulting in an acceptance rate of 26%.

I thank Haiying Shen (University of Virginia, USA) and George Pallis (The University of Cyprus, Cyprus) for coordinating the organisation of satellite workshops/mini-symposiums on hot topics such as Serverless To sErvE moRe at Scale (STEERS), Secure IoT, Edge and Cloud systems (SIoTEC), Cloud-to-Things continuum: towards the convergence of IoT, Edge and Cloud Computing (Cloud2Things 2021), Secure Mobile Cloud Computing, and Network-Aware Big Data Computing (NEAC). I appreciate the efforts of the chairs of various workshops and their PC members for attracting and selecting top-quality papers for presentation at the conference. I appreciate dedicated efforts of Anne-Cecile Orgerie and Mohsen Amini as doctoral symposium chairs.

I thank Hari Subramoni and Joanna Kolodziej for organising and managing the poster session, Mohammad Goudarzi for the excellent management of the conference website, and publicity coordinators, Jithin Jose, Stefan Schulte, Bahman Javadi, Ching-Hsien Hsu, Carlos Westphall, Zhicheng Cai, Helene Coullon, Sukhpal Singh, and Gill Antonino Galletta, for helping us reach a broader community. I thank SCALE Challenge chairs, Yogesh Simmhan and Ivan Rodero, and all other chairs for their efforts in enhancing the conference program with interesting demos. I thank Adel Toosi, Mohammad Goudarzi and Lisa O'Conner for their support in ensuring the publication of the conference proceedings in record time. I would like to offer my special appreciation to leading volunteers of the local organizing committee, led by Shashikant Ilager and Mohammad Goudarzi, for their dedicated services. I would like to thank Marie Trinh for managing registrations and Tricia Yamaguchi for her friendly services in finalising various contracts and budgets as an IEEE representative. Thanks are also due to our sponsors, namely, IEEE, ACM, TCSC, and organization supporters from Melbourne's CLOUDS Lab.

Ultimately, the success of the conference will be judged by how well the delegates have participated, learnt, interacted, and established contacts with other researchers in different fields. The Committees and the sponsors have provided the funding, the venue, and the environment to allow these objectives to be achieved. It is now up to all of us to ensure that the conference is an outstanding success.

I hope to host one of the future CCGrid events in Melbourne so that you will be able enjoy your visit to multicultural Melbourne and beautiful Australia! For now, I wish everyone a successful, stimulating, and rewarding meeting and look forward to seeing you all CCGrid 2020 and 2021 participants in virtually in Melbourne!

Thank you for your cooperation, understanding, and support.



Dr. Rajkumar Buyya, Redmond Barry Distinguished Professor Director, Cloud Computing and Distributed Systems (CLOUDS) Lab School of Computing and Information Systems The University of Melbourne, Australia http://www.cloudbus.org/

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Message from the Program Chair

The 21th IEEE/ACM International Symposium on Cluster, Cloud, and Internet Computing program contains 60 high-quality technical papers selected from 230 submissions from 47 different countries (26% acceptance rate). The great majority of papers received three or more reviews, and we ensured that all borderline papers received at least three reviews and were discussed electronically by the Program Committee before deciding on acceptance or rejection. Unfortunately, we had to decline many worthy submissions.

Following are the accepted paper statistics by topic:

Торіс	submissions	accepted	PC member
Sustainable and Green Computing	8	1	17
Cyber-Security and Privacy	28	4	17
Storage and I/O Systems	28	9	22
Programming Models and Runtime Systems	33	10	35
Architecture, Networking, Data Centers	48	14	31
Applications: Data Science, Artificial Intelligence, Cyber-Physical Systems, etc.	56	18	26
Internet Computing Frontiers: Edge, Fog, Serverless, Lambda, Streaming, etc.	64	22	36
Performance Modeling and Evaluation	70	16	46
Resource Management and Scheduling	76	26	42

Statistics by Topic

This high-quality program would not have been possible if not for the very hard work of 229 Program Committee members, including our colleagues, Program Vice-Chairs of the various topics. For Internet Computing Frontiers: Edge, Fog, Serverless, Lambda, Streaming: Jesus Carretero (Univ Carlos 3, Madrid, Spain), Weifa Liang (Australian National University, Australia); Architecture, Networking, Data Centers: Dhabaleswar K. Panda (Ohio State University, Columbus, USA), Di Wu (Sun Yat-Sen University, China); Storage, and I/O Systems: Suren Byna (Lawrence Berkeley National Lab, USA), Beomseok Nam (SungKyunKwan University, Korea); Programming Models and Runtime Systems: Cho-Li Wang (The University of Hong Kong), Bahman Javadi (Western Sydney University, Australia); Scheduling and Resource Management: Eddy Caron (ENS Lyon, France), Bingsheng He (National University of Singapore, Singapore); Performance Modeling and Evaluation: Hai Jin (Huazhong University of Science and Technology (HUST), China), Alba Cristina Magalhaes Alves de Melo (University of Brasilia, Brazil); Cyber-Security and Privacy: Miguel Correia (University of Lisbon, Portugal), Surya Nepal, (Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia); Sustainable and Green Computing: Patricia Stolf (IRIT, Toulouse, France), Wu Feng (Virginia Tech, USA); Applications: Data Science, Artificial Intelligence, Cyber-Physical Systems: Paul Roe (QUT, Australia), Susumu Date (Osaka University, Japan).

We also are indebted to the additional reviewers who volunteered their time and effort to make this the best possible CCGrid technical program. We also want to especially thank Rajkumar Buyya, the CCGri2021 General chair for his never-ending guidance. Last but not least, we want to thank the technical paper authors for submitting their research results and presenting them to the CCGrid community. Without their work, this conference would not have been possible.

We have selected the best papers for the CCGrid 2021 conference:

- First prize: Best paper: "DLIO: A Data-Centric Benchmark for Scientific Deep Learning Applications", Hariharan Devarajan, Huihuo Zheng, Anthony Kougkas, Xian-He Sun and Venkatram Vishwanath.
- Second prize: "A Two-Sided Matching Model for Data Stream Processing in the Cloud-Fog Continuum", Narges Mehran, Dragi Kimovski and Radu Prodan.
- Third prize: "Characterizing Input-sensitivity in Tightly-Coupled Collaborative Graph Algorithms", Jacob Hope, Mikel Gjergji, Johana Di Girolamo, Marco Alvarez and Apan Qasem

We decided that given the Covid-19 pandemic, CCGrid 2021 is going to be online together with paper presentations of CCGrid2020 accepted authors. But this will not stop the CCGrid dynamism and now, it is your time to enjoy the CCGrid 2021 accepted publications!



Laurent Lefevre Inria, ENS Lyon, France



Stacy Patterson Rensselaer Polytechnic Institute, USA



Young Choon Lee Macquarie University, Australia

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Serverless To sErvE moRe at Scale (STEERS 2021)

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The 3rd IEEE/ACM International Workshop on Network-Aware Big Data Computing (NEAC'21)

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