

Founding Editors

Gerhard Goos

Karlsruhe Institute of Technology, Karlsruhe, Germany

Juris Hartmanis

Cornell University, Ithaca, NY, USA

Editorial Board Members

Elisa Bertino

Purdue University, West Lafayette, IN, USA

Wen Gao

Peking University, Beijing, China

Bernhard Steffen 

TU Dortmund University, Dortmund, Germany

Gerhard Woeginger 

RWTH Aachen, Aachen, Germany

Moti Yung

Columbia University, New York, NY, USA

More information about this series at <http://www.springer.com/series/7407>

Ivona Brandic · Thiago A. L. Genez ·
Ilia Pietri · Rizos Sakellariou (Eds.)


Algorithmic Aspects of Cloud Computing


5th International Symposium, ALGOCLOUD 2019
Munich, Germany, September 10, 2019
Revised Selected Papers

Editors

Ivona Brandić 
Vienna University of Technology
Vienna, Austria

Ilia Pietri 
Intracom Telecom
Paiania, Greece

Thiago A. L. Genez 
Department of Engineering
University of Cambridge
Cambridge, UK

Rizos Sakellariou 
University of Manchester
Manchester, UK

ISSN 0302-9743 ISSN 1611-3349 (electronic)
Lecture Notes in Computer Science
ISBN 978-3-030-58627-0 ISBN 978-3-030-58628-7 (eBook)
<https://doi.org/10.1007/978-3-030-58628-7>

LNCS Sublibrary: SL1 – Theoretical Computer Science and General Issues

© Springer Nature Switzerland AG 2020

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

The International Symposium on Algorithmic Aspects of Cloud Computing (ALGO CLOUD) is an annual event that aims to tackle the diverse new topics in the emerging area of algorithmic aspects of computing and data management in the cloud.

The aim of the symposium is to bring together international researchers, students, and practitioners to present research activities and results on topics related to algorithmic, design, and development aspects of modern cloud-based systems.

As in previous years, paper submissions were solicited through an open call for papers. ALGO CLOUD welcomes submissions on all theoretical, design, and implementation aspects of modern cloud-based systems. We are particularly interested in novel algorithms in the context of cloud computing, cloud architectures, as well as experimental work that evaluates contemporary cloud approaches and pertinent applications. We also welcome demonstration manuscripts, which discuss successful elastic system developments, as well as experience/use-case articles and reviews. Contributions may span a wide range of algorithms for modeling, practices for constructing, and techniques for evaluating operations and services in a variety of systems, including but not limited to, virtualized infrastructures, cloud platforms, data centers, cloud-storage options, cloud data management, non-traditional key-value stores on the cloud, HPC architectures, etc.

Topics of interest addressed by this workshop include, but are not limited to:

- Analysis of algorithms and data structures
- Resource management and scheduling
- Data center and infrastructure management
- Privacy, security, and anonymization
- Cloud-based applications
- Virtualization and containers
- Performance models
- Cloud deployment tools and their analysis
- Novel programming models
- Storage management
- Fog and edge computing
- Economic models and pricing
- Energy and power management
- Big data and the cloud
- Network management and techniques
- Caching and load balancing

ALGO CLOUD 2019 took place on September 10, 2019, in Munich, Germany. It collocated and was part of ALGO 2019 (September 9–13, 2019), the major annual congress that combines the premier algorithmic conference European Symposium on Algorithms (ESA), and a number of other specialized symposiums and workshops, all

related to algorithms and their applications, making ALGO the major European event for researchers, students, and practitioners in algorithms.

There was a positive response to the ALGO CLOUD 2019 call for papers. The diverse nature of papers submitted demonstrated the vitality of the algorithmic aspects of cloud computing. All submissions went through a rigorous peer-review process and were reviewed by at least three Program Committee (PC) members. Following their recommendations, the PC chairs accepted seven original research papers in a wide variety of topics that were presented at the workshop. We would like to thank all PC members for their significant contribution in the review process.

The program of ALGO CLOUD 2019 was complemented with a highly interesting keynote, entitled “New Horizons in IoT Workflows Provisioning in Edge and Cloud Datacentres for Fast Data Analytics,” which was delivered by Rajiv Ranjan (Newcastle University, UK), and an informative and well-thought-out tutorial entitled “Algorithms for a Smart Construction Environment,” which was delivered by Vlado Stankovski (University of Ljubljana, Slovenia). We wish to express our sincere gratitude to both our esteemed invitees for their contributions.

Finally, we would like to thank all authors who submitted their research work to ALGO CLOUD and the Steering Committee for volunteering their time.

We hope that these proceedings will help researchers, students, and practitioners understand and be aware of state-of-the-art algorithmic aspects of cloud computing, and that they will stimulate further research in the domain of algorithmic approaches in cloud computing in general.

September 2019

Ivona Brandic
Thiago A. L. Genez
Ilia Pietri
Rizos Sakellariou

Organization

Steering Committee

Spyros Sioutas	University of Patras, Greece
Peter Triantafillou	University of Warwick, UK
Christos D. Zaroliagis	University of Patras, Greece

Symposium Chairs

Ivona Brandic	Vienna University of Technology, Austria
Thiago A. L. Genez	University of Cambridge, UK
Ilia Pietri	Intracom SA, Greece
Rizos Sakellariou	The University of Manchester, UK

Program Committee

Olivier Beaumont	Inria Bordeaux, France
Luiz Fernando Bittencourt	University of Campinas, Brazil
Valeria Cardellini	University of Rome Tor Vergata, Italy
Alex Delis	University of Athens, Greece
Elisabetta Di Nitto	Politecnico di Milano, Italy
Katerina Doka	National Technical University of Athens, Greece
Fanny Dufossé	Inria Grenoble, France
Thomas Fahringer	University of Innsbruck, Austria
Sarunas Girdzijauskas	KTH Royal Institute of Technology, Sweden
Anastasios Gounaris	Aristotle University of Thessaloniki, Greece
Raffaele Montella	Parthenope University of Naples, Italy
George Pallis	University of Cyprus, Cyprus
Alessandro Papadopoulos	Mälardalen University, Sweden
Guido Proietti	University of L'Aquila, Italy
Krzysztof Rządca	University of Warsaw, Poland
Rafael Brundo Uriarte	IMT Lucca, Italy

Additional Reviewer

Thanh-Phuong Pham	University of Innsbruck, Austria
-------------------	----------------------------------

New Horizons in IoT Workflows Provisioning in Edge and Cloud Datacentres for Fast Data Analytics (Keynote Talk)

Rajiv Ranjan

Newcastle University, UK
raj.ranjan@ncl.ac.uk

Abstract. Supporting Internet of Things (IoT) workflow enactment/execution on a combination of computational resources at the network edge and at a datacentre remains a challenge. Increasing volumes of data being generated through smart phones and IoT devices (which can vary significantly in scope and capability), need to be processed in a timely manner [2]. Current practice involves using edge nodes (e.g. sensors or other low-capacity devices) as a means to acquire/collect data (i.e. as an “observation” mechanism). Subsequently, this data is transmitted to a datacentre/cloud for analysis/insight. Increasingly, the limitation with the use of a large-scale, centralised datacentre is being realised (such as speed of response for latency-sensitive applications), with the emergence of a number of paradigms to address this concern – such as fog computing, edge computing, Cloud-of-Things, etc. [1]. All of these propose the use of dedicated servers (with varying capacity and capability) within micro/nano datacentres at the network edge, to overcome latency constraints associated with moving data to a central facility and (lack of use of) increasing computational capability within edge devices. These paradigms also closely align with work in content distribution networks (e.g. from Akamai CDNs), which attempt to place data servers within one (or a small number of) hop-of-end users (currently 85% of users are supported in this way, with >175K Akamai servers).

A key objective of this keynote talk is to understand how such emerging paradigms can be used to enable cloud systems (supported through large scale computational facilities) to be “stretched” to the network edge, to enable data-driven IoT workflows to be enacted efficiently over such combined infrastructure. We propose the combined use of (varying) capability at the network edge (referred to as an Edge DataCentre (EDC)) with capability within a Cloud DataCentre (CDC). Collectively, IoT devices and edge resources, like gateways (Raspberry Pi 3), software-defined network systems (Huawei CloudEngine 6800), and smart phones equipped with sensors, constitute a new set of computing resources – and are potential components of an EDC [1, 3]. This keynote talk will have the following outline:

1. Overview of the research challenges involved with composing and orchestrating complex IoT workflows in cloud-edge continuum infrastructure.
2. Discuss two case studies in healthcare and smart cities domain to understand how data-driven workflows can be applied to create/compose next-generation IoT applications.

3. Discuss our experience with running the UK's largest IoT infrastructure, namely, the Urban Observatory (<http://www.urbanobservatory.ac.uk/>).

References

1. Nardelli, M., Nastic, S., Dustdar, S., Villari, M., Ranjan, R.: Osmotic flow: osmotic computing + IoT workflow. *IEEE Cloud Comput.* **4**(2), 68–75 (2017). <https://doi.org/10.1109/MCC.2017.22>
2. Ranjan, R., et al.: The next grand challenges: integrating the internet of things and data science. *IEEE Cloud Comput.* **5**(3), 12–26 (2018). <https://doi.org/10.1109/MCC.2018.032591612>
3. Villari, M., Fazio, M., Dustdar, S., Rana, O., Ranjan, R.: Osmotic computing: a new paradigm for edge/cloud integration. *IEEE Cloud Comput.* **3**(6), 76–83 (2016). <https://doi.org/10.1109/MCC.2016.124>

Contents

Algorithms for a Smart Construction Environment	1
<i>Petar Kochovski and Vlado Stankovski</i>	
Developing a Cloud-Based Algorithm for Analyzing the Polarization of Social Media Users	15
<i>Loris Belcastro, Fabrizio Marozzo, Domenico Talia, and Paolo Trunfio</i>	
Coordinated Data Flow Control in IoT Networks	25
<i>Nipun Balan Thekkummal, Devki Nandan Jha, Deepak Puthal, Philip James, and Rajiv Ranjan</i>	
A Monitoring System for Distributed Edge Infrastructures with Decentralized Coordination	42
<i>Roger Pueyo Centelles, Mennan Selimi, Felix Freitag, and Leandro Navarro</i>	
A Container-Driven Approach for Resource Provisioning in Edge-Fog Cloud	59
<i>Hamid Mohammadi Fard, Radu Prodan, and Felix Wolf</i>	
Self-adaptive Container Deployment in the Fog: A Survey	77
<i>Valeria Cardellini, Francesco Lo Presti, Matteo Nardelli, and Fabiana Rossi</i>	
Security-Aware Database Migration Planning	103
<i>K. Subramani, Bugra Caskurlu, and Utku Umur Acikalin</i>	
Scalable and Hierarchical Distributed Data Structures for Efficient Big Data Management	122
<i>Spyros Sioutas, Gerasimos Vonitsanos, Nikolaos Zacharatos, and Christos Zaroliagis</i>	
Author Index	161