IEEE computer society

IEEE

The IEEE International Conference on Cloud Engineering (IC2E) conference series provides a high-quality and comprehensive forum, where researchers and practitioners can exchange information on engineering principles, enabling technologies, and practical experiences as related to cloud computing. By bringing together experts that work on different levels of the cloud stack—systems, storage, networking, platforms,databases, analytics, and applications, IC2E offers an end-to-end view on the challenges and technologies in cloud computing, fosters research that addresses the interaction between different layers of the stack, and ultimately drives cloud-based innovation in business and society.

The 2019 IEEE International Conference on Fog Computing (ICFC 2019), colocated with the IEEE International Conference on Cloud Engineering (IC2E), brings together researchers and practitioners across academia, industry, and governments to exchange visions, technical challenges, and research outcomes in a single forum. ICFC takes a broad view of Fog Computing, including computation, connectivity, mobility, sensing and actuation, theories, and systems.

WELCOME MESSAGE FROM THE IC2E GENERAL CHAIRS

We are delighted to welcome you to IEEE International Conference on Cloud Engineering (IC2E) 2019 in Prague, Czech Republic! It provides a high-quality and comprehensive forum, where researchers and practitioners can exchange information on engineering principles, enabling technologies, and practical experiences as related to cloud computing.

IC2E 2019 hosts an exciting technical program, with two keynote talks by leaders in the field, regular and invited research paper presentations, tutorials, and co-located workshops. By bringing together experts that work on different levels of the cloud stack - systems, storage, networking, platforms, databases, analytics, and applications, IC2E offers an end-to-end view on the challenges and technologies in cloud computing, fosters research that addresses the interaction between different layers of the stack, and ultimately drives cloud-based innovation in business and society.

We are immensely grateful to the many researchers who have shaped the conference program. In particular, we thank the Program Chairs, Ivona Brandic, (Vienna University of Technology, Austria) and Dejan Milojicic (Hewlett Packard Labs, USA), for their leadership and for ensuring a high-quality program. A carefully selected TPC has done a great job in reviewing the research submissions. We also acknowledge the members of the IC2E Steering Committee, for invaluable help and guidance throughout the many months leading to the conference. Hui Lei deserves special thanks for providing us with his advice at all stages of the conference organization.

We are very grateful to the other Chairs of the Organizing Committee, including Short Papers Program Chair, Fabio A. Oliveira (IBM Research, USA), Doctoral Symposium Chair, Peng Li (The University of Aizu, Japan), Future of Computing Co-chairs, Ozalp Babaoglu (University of Bologna, Italy), Tom Conte (Georgia Institute of Technology, USA), Erik DeBenedictis (Sandia Labs, USA) and Hironori

Kasahara (Waseda University, Japan), along with all members of the Program Committee; Workshops Chair, Andreas Opdahl (University of Bergen, Norway); Tutorials Chair, Weifa Liang (The Australian National University, Australia); Publicity Chairs, Xiaokang Zhou (Shiga University, Japan), Scott Fowler (Linköping University, Sweden), Dalvan Griebler, (Pontifical Catholic University of Rio Grande do Sul, Brazil), Stanko Novaković (VMware, USA); Web and Information Chair, Zichuan Xu (Dalian University of Technology, China); Proceedings Chair, Vincezo de Maio (Vienna University of Technology, Austria). We also give our sincere thanks to the IEEE CPS team for their immense help in preparing the proceedings for publication.

Last but not least, we thank all authors, tutorial presenters, workshop organizers, and conference participants for making IC2E 2019 a success. We wish you will find IEEE IC2E 2019 to be an inspiring, informative and fruitful experience.

We welcome you to Prague and we sincerely hope that you will enjoy IC2E 2019!

Pavel Tvrdik
Song Guo
IEEE IC2E 2019 General Chairs

We thank the contributions of the PC members and authors, and hope you enjoy the technical program we have put together.

Ivona Brandic
IC2E Program Committee Co-chair

Dejan Milojicic
IC2E Program Committee Co-chair

WELCOME MESSAGE FROM THE ICFC GENERAL CHAIRS

We would like to welcome you to the first IEEE International Conference on Fog Computing (ICFC 2019). ICFC in its first edition is held in the cultural city of Prague during June 24-26, 2019. Prague, capital city of the Czech Republic, is bisected by the Vltava River. Nicknamed "the City of a Hundred Spires," it's known for its Old Town Square, the heart of its historic core, with colorful baroque buildings, Gothic churches and the medieval Astronomical Clock, which gives an animated hourly show. Completed in 1402, pedestrian Charles Bridge is lined with statues of Catholic saints. Prague is home to a number of well-known cultural attractions, many of which survived the violence and destruction of 20th-century Europe. Main attractions include Prague Castle, Charles Bridge, Old Town Square with the Prague astronomical clock, the Jewish Quarter, Petřín hill and Vyšehrad. Since 1992, the extensive historic center of Prague has been included in the UNESCO list of World Heritage Sites.

On behalf of the organizing committee of the conference, we would like to express to all the participants who will attend the conference, our cordial welcome and great gratitude. The ICFC is a forum that brings together researchers and practitioners across academia, industry, and governments to exchange visions, technical challenges, and research outcomes in a single forum. ICFC takes a broad view of Fog Computing, including computation, connectivity, mobility, sensing and actuation, theories, and systems. Fog computing is the extension of cloud computing into its edge and the physical world to meet the data volume and decision velocity requirements in many emerging applications, such as augmented and virtual realities (AR/VR), cyber-physical systems (CPS), intelligent and autonomous systems, and mission-critical systems. The boundary between centralized, powerful computing cloud and massively distributed, Internet connected sensors, actuators, and things is blurred in this

new computing paradigm.

ICFC consists of a single track program that attracted high-quality research papers which highlight the foundational work that strives to push beyond the limits of existing technologies, including experimental efforts, and innovative systems. Many individuals have contributed to the success of the conference. We would like to express our special thanks to Professors Gelenbe and Liu and their Program Committee Members for their excellent work in creating an exciting technical program. Our gratitude goes to the Publicity Co-Chairs, Professors Delicato and Fischer for publicizing the event widely. Also, we are appreciative for the efforts of Professor Bermbach (Tutorials and Workshops Chair), Professor Taheri (Publication Chair), and Dr. Li (Webmaster), for managing the different conference logistics.

We are indebted to the two distinguished speakers, Professor Mung Chiang and Mr. Kirk Bresniker, for agreeing to keynote ICFC. Finally, we would like to thank all the authors who submitted their papers to the conference, and we look forward to welcoming you to ICFC 2019 and fascinating Prague. We are certain that you will find the inaugural event full of stimulating ideas and discussions.

Hui Lei
Albert Y. Zomaya
IEEE ICFC 2019 General Chairs

We thank the contributions of the PC members and authors, and hope you enjoy the technical program we have put together.

Erol Gelenbe
ICFC Program Committee Co-chair

Jie Liu
ICFC Program Committee Co-chair

Date & Venue

June 24 – 27, 2019

The Czech Association of Scientific and Technical Societies
Novotneho Lavka 1
Prague 1
Czech Republic

Social Program

Welcome Drink
MONDAY, June 24, 2018, 17:30-19:30
The Czech Association of Scientific and Technical Societies
The conference venue

Sightseeing Tour of Prague & Conference Dinner with a Boat Cruise
WEDNESDAY, June 26, 2019
18:00   Meeting point at the conference venue (outside)
18:00-20:00   Walking tour finished on the boat
20:00-22:00   Boat cruise with Conference dinner
The conference dinner will be held with the Boat trip on the Vltava river
Mooring/Marina, NO. 3, **BOAT "LABE"**
Dvorak´s waterfront, Under the Čechův bridge
Dress code: CASUAL

Contacts

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IC2E & ICFC 2019 Keynotes

The Next Decade of Fog

Speaker: Mung Chiang (Purdue University)

Bio: Mung Chiang is the John A. Edwardson Dean of the College of Engineering and the Roscoe H. George Professor of Electrical and Computer Engineering at Purdue University. Previously he was the Arthur LeGrand Doty Professor of Electrical Engineering at Princeton University, where he also served as Director of Keller Center for Innovations in Engineering Education and the inaugural Chairman of Princeton Entrepreneurship Council. His research on networking received the 2013 Alan T. Waterman Award, the highest honor to US young scientists and engineers. His textbook "Networked Life," popular science book "The Power of Networks," and online courses reached over 250,000 students since 2012. He founded the Princeton EDGE Lab in 2009, which bridges the theory-practice gap in edge networking research by spanning from proofs to prototypes. He also co-founded a few startup companies in mobile data, IoT and AI, and co-founded the global nonprofit Open Fog Consortium.

Mung Chiang

Adapting cloud engineering principles to tomorrow's challenges: Edge-Centric, Data-Driven, Cloud-Enabled

Speaker: Kirk Bresniker (Hewlett Packard)

Abstract: The principles of Cloud Engineering and the Hyperscale data centers they have enabled have lowered the barriers to innovation globally, simplifying access to cutting edge computational resources for everyone from core enterprise developers to entrepreneurs and startups. But underpinning this success are a series of assumptions rooted in Moore's Law performance scaling and the asymmetric data flow between systems of engagement and their mobile users. Those assumptions have led to a recipe for consolidation and monocultures at every level, which while it is efficient, is also fragile just when the so much is shifting. Whether it is in billions of intelligent edge devices operating in real time with a paucity of resources or an exascale HPC data center where any inefficiency is mercilessly made material by sheer scale, new challenges demand precision as well as efficiency of access. It's time to challenge the status quo. How can we extend the cloud efficiency gains won at the singular point of Hyperscale across the entire continuum from edge to core?

Bio: Kirk Bresniker is Chief Architect of Hewlett Packard Labs and a Hewlett Packard Enterprise Fellow and Vice President. He joined Labs in 2014 to drive The Machine Research and Advanced Development program, leading teams across Labs and across HPE business units with the goal of demonstrating and evangelizing the benefits of Memory-Driven Computing. His current focus is accelerating the transfer of technologies from The Machine research program in order to drive differentiating value into existing product categories as well as disruptive new offerings. Prior to joining Labs, Kirk was Vice President and Chief Technologist in the HP Servers Global Business Unit representing 25 years of innovation leadership.

Joining HP as a PA-RISC system hardware engineer in 1989, he has always been a part of the Business Critical Systems team. In 1993, he was the design lead for the first HP entry-level multi-processor system which broke new ground in terms of low-cost, high performance design. Following that, he was the design lead for the entire D-class PA-RISC product family, one of the highest volume BCS product families ever introduced. Starting in 1997, Kirk began a decade-long research and development effort to develop novel new modular system architectures which would eventually become a new category of integrated hardware and software offerings known as Blade Servers. This early work was eventually refined and blended with the contributions of the combined HP-Compaq merger lead to become HP BladeSystem c-Class, the undisputed leader in Blade Server platforms. In 1999, he was the key architect for all PA-RISC and Itanium entry and mid-range servers and oversaw a complete re-vamp of the product line and prepared for the PA-RISC to Itanium transition. From 2000 onwards, Kirk oversaw the transformation of the HP-UX UNIX and fault tolerant NonStop to blades to extend BladeSystem to the mission critical market, culminating in the Superdome X mission critical X86 blade platform, the highest performing HPE Mission Critical ProLiant system ever created. It was also during this period that he led the earliest investigations into what would become The Machine Research program.

Kirk current holds 28 US and 10 foreign patents in areas of modular platforms and blade systems, integrated circuits, and power and environmental control. He graduated in 1989 Cum Laude from Santa Clara University with a BSEE and was also a member of the Humanities Honors program.

Kirk Bresniker

SCIENTIFIC PROGRAM
MONDAY, June 24, 2019

Hall 319 (3rd floor)
DAMOVE AND SQUEET COLOCATED WORKSHOPS

13:30 Welcome and Introduction

13:40 DATA MOVEMENT IN FOG COMPUTING (DAMOVE)

13:40 Towards Fog Network Utility Maximization (FoNUM) for Managing Fog Computing Resources
V. Marbukh

14:00 IoT Data Processing in the Fog: Functions, Streams, or Batch Processing?
T. Pfandzelter and D. Bermbach

14:20 KEYNOTE LECTURE
Performance Measurement and Prediction in New Emerging Technologies
Prof. Umberto Villano, University of Sannio

14:50 Coffee break

15:00 MEASURING AND GUARANTEEING QOS IN NEW EMERGING TECHNOLOGIES (SQUEET)

15:00 Detecting IoT Malware by Markov Chain Behavioral Model
M. Ficco

15:20 A secure inter-domain communication for IoT devices
A. Anand, A. Galletta, A. Celesti, M. Fazio, M. Villari

15:40 Continuous Benchmarking: Using System Benchmarking in Build Pipelines
M. Grambow, F. Lehmann, D. Bermbach

16:00 Benchmarking embedded platforms in physical and virtual environments
S. Venticinque

16:20 PANEL SESSION
Service Level Agreement and Quantitative Evaluation in the Practice
prof. Massimiliano Rak
- Dr. Giuseppe Di Modica, University of Catania
- Prof. Massimiliano Rak, University of Campania Luigi Vanvitelli
- Prof. Umberto Villano, University of Sannio
- Dr. Vrettos Moulos, National Technical University of Athens

17:20 Closing

MONDAY

Hall 318 (3rd floor)
TUTORIAL

9:00 SOFTWARE AND SYSTEM DISCOVERY: AUTOMATED CLOUD ANALYTICS FOR THE CONTINUOUS DEVELOPMENT ERA

Ayse K. Coskun, Electrical and Computer Engineering Department, Boston University (BU), USA

Shripad Nadgowda, IBM T.J. Watson Research Center in Yorktown Heights, NY, USA

Anthony Byrne, Electrical and Computer Engineering Department, Boston University (BU), USA

12:30 Lunch

TUTORIAL

13:30 QUALITY AND FEEDBACK TECHNIQUES IN KUBERNETES APPLICATION ENGINEERING

Josef Spillner, Service Prototyping Lab, Zurich University of Applied Sciences, Switzerland

Sebastiano Panichella, Service Prototyping Lab, Zurich University of Applied Sciences, Switzerland

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Hall 315 (3rd floor)
TUTORIAL

13:30 MOBILE EDGE CLOUD FOR CYBER PHYSICAL SYSTEM APPLICATIONS

Sayed Chhattan Shah, Hankuk University of Foreign Studies, South Korea

MONDAY

SCIENTIFIC PROGRAM
TUESDAY, June 25, 2019

Hall 319 (3rd floor)
IC2E & ICFC

8:30   **Opening ceremony, The best paper award nomination**

9:00   **KEYNOTE LECTURE (H. LEI)**
        The Next Decade of Fog
        Mung Chiang

10:00   **Coffee break**

IC2E

10:30   **LONG SESSION 1: APPLICATION/AI (T. RAUSCH)**

10:30   **ModelOps: Cloud-based Lifecycle Management for Reliable and Trusted AI**
        Waldemar Hummer, Vinod Muthusamy, Thomas Rausch, Parijat Dube, Kaoutar El Maghraoui

11:00   **A Flexible Distributed Hypergraph Processing System**
        Benjamin Heintz, Rankyung Hong, Shivangi Singh, Gaurav Khandelwal, Corey Tesdahl,
        Abhishek Chandra

11:30   **BARISTA: Efficient and Scalable Serverless Serving System for Deep Learning Prediction Services**
        Anirban Bhattacharjee, Ajay Dev Chhokra, Zhuangwei Kang, Hongyang Sun,
        Aniruddha Gokhale

12:00   **Lunch**

13:30   **CLOUD CONTROL (A. GAVRILOVSKA)**

13:30   **Towards Self-Managing Cloud Storage with Reinforcement Learning**
        Ridwan Rashid Noel, Rohit Mehra, Palden Lama

14:00   **Information Models: Creating and Preserving Value in Volatile Cloud Resources**
        Chaojie Zhang, Varun Gupta, Andrew A. Chien

14:30   **Toward a Workload Allocation Optimizer for Power Saving in Data Centers**
        Ying-Feng Hsu; Hayato Kuwahara; Kazuhiro Matsuda; Morito Matsuoka

15:00   **Coffee break**

IC2E & ICFC

15:30   **INVITED PAPERS (S. GUO)**

15:30   **Edge-Cloud Orchestration: Strategies for Service Placement and Enactment**
        Ioan Petri, Omer Rana, Ali Reza Zamani, Yacine Rezgui

TUESDAY

16:00 **Addressing the Fragmentation Problem in Distributed and Decentralized Edge Computing: A Vision**
Ketan Bhardwaj, Matt Saunders, Ada Gavrilovska, Vlad Kolesnikov, Mugdha Bondre, Meghana Babu, Jacob Walsh

16:30 **Edge-assisted Detection and Summarization of Key Global Events from Distributed Crowd-sensed Data**
Abdulrahman Fahim, Ajaya Neupane, Evangelos Papalexakis, Lance Kaplan, Srikanth V. Krishnamurthy, Tarek Abdelzaher

17:00 **Edge Intelligence: The Convergence of Humans, Things, and AI**
Thomas Rausch; Schahram Dustdar

17:00 **Closing**

Hall 318 (3rd floor)

10:00 **Coffee break**

ICFC

10:30 **LONG SESSION 1: MODELS AND TOOLS (E. GELENBE)**

10:30 **Towards a Serverless Platform for Edge Computing**
Danilo Mendonca, Luciano Baresi

10:50 **Random Neural Networks and Deep Learning for Attack Detection at the Edge***
Olivier Brun, Yonghua Yin

11:10 **An acceleration method for docker image update**
Jiwei Xu, Zhigang Lu

11:30 **Cognitive packet network for self-aware adaptive clouds***
Lan Wang

12:00 **Lunch**

13:30 **SECURITY (I. BRANDIC)**

13:30 **A Fog Computing Architecture to Share Sensor Data by Means of Blockchain Functionality**
Hendrik Cech, Marcel Großmann, Udo R. Krieger

13:50 **Cognitive Routing for Improvement of IoT Security***
Mateusz Nowak, Sławomir Nowak, Joanna Domańskai

14:10 **An Performance Evaluation of Data Protection Mechanisms for Resource Constrained IoT Devices**
Clemens Lachner, Schahram Dustdar

14:30 **Detecting and Mitigating Storm Attacks in Mobile Access to the Cloud***
Mihajlo Pavloski

15:00 **Coffee break**

TUESDAY

SCIENTIFIC PROGRAM
WEDNESDAY, June 26, 2019

Hall 319 (3rd floor)
IC2E & ICFC

9:00	**KEYNOTE LECTURE (D. MILOJICIC)**

Adapting cloud engineering principles to tomorrow's challenges: Edge-Centric, Data-Driven, Cloud-Enabled
Kirk Bresniker

10:00   **Coffee break**

IC2E

10:30	**FUTURE OF COMPUTING (I. BRANDIC)**

10:30   **Future of Computing is Boring (and that is exciting!)**
Aleksander Slominski; Vinod Muthusamy; Vatche Ishakian

11:00   **Host Hypervisor Trace Mining for Virtual Machine Workload Characterization**
Hani Nemati, Seyed Vahid Azhari, Michel R. Dagenais

11:30   **ModelOps: Cloud-based Lifecycle Management for Reliable and Trusted AI**
Waldemar Hummer, Vinod Muthusamy, Thomas Rausch; Parijat Dube, Kaoutar El Maghraoui

12:00   **Lunch**

13:30	**CLOUD TESTING (L. GAO)**

13:30   **A Study on Container Vulnerability Detection**
Olufogorehan Tunde-Onadele, Jingzhu He, Ting Dai; Xiaohui Gu

13:45   **Critical Influential Factors For Software Testing-as-a-Service Adoption: Findings From Systematic Literature Review**
Sikandar Ali, Hongqi Li

14:00 – 14:30   **ShadeNF: Testing Online Network Functions**
Hui Lu, Abhinav Srivastava, Yu Sun

15:30   **Coffee break**

16:00	**INVITED PAPERS (A.A. SLOMINSKI)**

16:00   **Importance of Application-level Resource Allocation in Multi-cloud Deployments**
Zoran Dimitrijevic, Cetin Sahin, Christian Tinnefeld

16:30   **Understanding Synchronization Costs for Distributed ML on Transient Cloud Resources**
Lurdh Pradeep Reddy Ambati, David Irwin, Prashant Shenoy, Lixin Gao, and Jeannie Albrecht

17:00   **Query-Driven Descriptive Analytics for IoT and Edge Computing**
Symeonides et al.

17:30   **Closing**

WEDNESDAY

Hall 318 (3rd floor)

10:00 **Coffee break**

ICFC

10:30	**RESOURCE MANAGEMENT (H. LEI)**

10:30 **Balancing Energy Consumption and Losses with Energy Packet Network Models***
Josu Doncel, Jean-Michel Fourneau

10:50 **Autonomic Resource Management using Analytic Models for Fog/Cloud Computing**
Daniel A Menasce, Uma Tadakamalla

11:10 **Exploiting power-of-choices for load balancing in fog computing**
Roberto Beraldi, Hussein Alnuweiri

11:30 **Fuzzy Handoff Control in Edge Offloading**
Fani Basic, Atakan Aral and Ivona Brandic

11:50 – 12:10   **Fog Application Allocation for Automation Systems**
Marco Suter, Raphael Eidenbenz, Yvonne-Anne Pignolet, Ankit Singla

12:00 **Lunch**

13:30	**IOT AND STREAMING (D. MENASCE)**

13:30 **Optimizing Streaming Data Transfers for Bandwidth Usage and End-to-End Latency Between Fogs and Cloud**
Salman Memon, Muthucumaru Maheswaran

13:50 **Multi-layer Stream Orchestration with Flange**
Jeremy Musser

14:10 **A Scalable Architecture for Power Consumption Monitoring in Industrial Production Environments**
Sören Henning, Wilhelm Hasselbring, Armin Möbius

14:30 **Cost-Performance Trade-offs in Fog Computing for IoT Data Processing of Social Virtual Reality**
Songjie Wang, Samaikya Valluripally, Sai Shreya Nuguri, Reshmi Mitra, Khaled Salah, Prasad Calyam

15:00 **Coffee break**

15:30	**PLANNING (P. TVRDÍK)**

15:30 **MockFog: Emulating Fog Computing Infrastructure in the Cloud**
Jonathan Hasenburg, Martin Grambow, Elias Grünewald, Sascha Huk, David Bermbach

15:50 **EmuEdge: A Hybrid Emulator for Reproducible and Realistic Edge Computing Experiments**
Yukun Zeng, Mengyuan Chao, Radu Stoleru

16:10 **From back-of-the-envelop to informed estimation of edge computing benefits in minutes using Castnet**
Harshit Daga, Hobin Yoon, Ketan Bhardwaj, Ada Gavrilovska

16:30 **Edge Capacity Planning for Real Time Compute-Intensive Applications**
Marius Noreikis, Yu Xiao, Yuming Jiang

16:50 **Capacity Planning of Fog Computing Infrastructures under Probabilistic Delay Guarantee**
Ioanna Stypsanelli, Olivier Brun, Samir Medjiah, Balakrishna Prabhu

17:10 **Closing**

WEDNESDAY

SCIENTIFIC PROGRAM
THURSDAY June 27, 2019

Hall 319 (3rd floor)
IC2E

8:30	**CLOUD WORKLOAD MANAGEEMENT AND SCHEDULING (Z. DIMITRIJEVIC)**

8:30   **ConfAdvisor: A Performance-centric Configuration Tuning Framework for Containers on Kubernetes**
Tatsuhiro Chiba, Rina Nakazawa, Hiroshi Horii, Sahil Suneja, Seetharami Seelam

9:00   **Maintenance Scheduling for Cloud Infrastructure with Timing Constraints of Live Migration**
Shingo Okuno, Fumi Iikura, Yukihiro Watanabe

9:30   **ContainerVisor: Customized Control of Container Resource**

10:00   **Coffee break**

10:30	**PERFORMANCE MANAGEMENT (D. MILOJICIC)**

10:30   **Predicting the End-to-End Tail Latency of Containerized Microservices in the Cloud**
Joy Rahman, Palden Lama

11:00   **FECBench: A Holistic Interference-aware Approach for Application Performance Modeling**
Yogesh Barve, Shashank Shekhar, Ajay Chhokra, Shweta Khare, Anirban Bhattacharjee, Zhuangwei Kang, Hongyang Sun, Aniruddha Gokhale

11:30   **Analyzing AWS Spot Instance Pricing**
Gareth George, Rich Wolski, Chandra Krintz, John Brevik

11:45   **Closing**

THURSDAY