June 27–July 1, 2022
Portland, OR, USA

Association for
Computing Machinery

Advancing Computing
as a Science & Profession

MobiSys '22

Proceedings of the 2022

The 20th Annual International Conference on Mobile Systems, Applications and Services

Sponsored by:

ACM SIGMOBILE

Association for Computing Machinery

Advancing Computing as a Science & Profession

The Association for Computing Machinery
2 Penn Plaza, Suite 701
New York, New York 10121-0701

Notice to Past Authors of ACM-Published Articles
ACM intends to create a complete electronic archive of all articles and/or other material previously published by ACM. If you have written a work that has been previously published by ACM in any journal or conference proceedings prior to 1978, or any SIG Newsletter at any time, and you do NOT want this work to appear in the ACM Digital Library, please inform permissions@acm.org, stating the title of the work, the author(s), and where and when published.

ISBN: 978-1-4503-9185-6

Additional copies may be ordered prepaid from:
ACM Order Department
PO Box 30777
New York, NY 10087-0777, USA

Phone: +1 800 342-6626 (USA and Canada)
+1 212 626-0500 (Global)
Fax: +1 212 944-1318
Email: acmhelp@acm.org
Hours of Operation: 8:30 am–4:30 pm ET

MobiSys 2022
Welcome Message from the General Chairs

It is with great pleasure that we welcome you to the 20th anniversary of the ACM International Conference on Mobile Systems, Applications, and Services. After two virtual conferences held during the pandemic, and an uncertain outlook when planning this conference last Fall, we are delighted and relieved to host you in person in our beautiful hometown of Portland, Oregon.

A lot has changed in the past 20 years. Smartphones, a novel curiosity two decades ago, have revolutionized society and all aspects of human communication, with far reaching impacts across health, education, entertainment and finance. We can derive immense pride and satisfaction from the rich and varied technical contributions of our community undergirding this revolution. In the meantime, our community has embarked on new explorations across wearable computing, mobile and augmented reality, novel wireless technologies, networked drones, autonomous driving and embedded intelligence. With wonderment and unbridled optimism for the future, we gather to learn and celebrate the latest advances in our field.

We would like to take this opportunity to thank the hard work put in by our absolutely terrific organizing committee. Their effort was instrumental in putting together this strong program and organizing this event. The organizing committee was assembled with an inclusive lens, featuring researchers from around the world and particularly featuring women in many prominent roles to spotlight their vital importance to our community.

Our program chairs Junehwa Song and Aruna Balasubramanian, leading an excellent program committee, have assembled a high quality technical program. Befitting the reflective nature of this conference, our conference program features keynote talks by Fadel Adib, the SIGMOBILE Rockstar Award Winner; Andrea Goldsmith, the SIGMOBILE Outstanding Contribution Award Winner; and an industry keynote by Constantine Polychronopoulos from Juniper Networks.

Complementing the efforts of the program chairs, Tarek Abdelzaher has assembled a great and diverse lineup of speakers for IoT day, including stalwarts in the field such as Mani Srivastava, Chenyang Lu, Luca Mottola, Matthew Ceasar and Jae Kim.

Additionally, the conference provides several technical forums that are highly interactive and social. These include a poster session organized by chairs, Jiasi Chen and Marco Mezzavilla, a demonstration session organized by chairs, Sanjib Sur and Yasaman Ghasempour and a PhD forum, organized by David Burnett. Carlee Joe-Wong, our mentorship chair was instrumental in organizing the Networking Networking Women event. These events also provide a place where students can present their ideas to a supportive and constructive group and facilitate networking among early career researchers in the community.

VP Nguyen, our energetic workshops chair, has assembled five workshops that provide a venue for highly focused discussions across a broad spectrum of emerging topics, spanning embedded and mobile deep learning, digital biomarkers, body-centric computing systems, intelligent acoustic sensing and micro-aerial vehicle networks. These workshops would not be possible without the efforts of the workshop chairs, including Sofia Scataglini, Parama Pal, Fred Jiang, Shahriar Nirjon, Nirupam Roy, Bashima Islam, Stylianos Venieris, Qing Wang, Stefanos Laskaridis, Kaushik Chowdhury, Wael Jaafar, Tauhidur Rahman, Alex Mariakakis, and Edward Wang.

Wen Hu and Yuan He, our highly focused proceedings chairs, ensured that the conference proceedings were completed on time with minimal fuss. Inseok Hwang and Nirupam Roy took on the important role of Artifact Evaluation chairs in evaluating all technical papers with rigor.

Behind the scenes, Wu-chang Feng has coordinated every aspect of local arrangements, from hotel site selection, banquet arrangements to meal planning. He has also been an excellent sounding board on nearly every organizational issue. Ashwin Ashok took on a very heavy workload as registrations chair and deserves much gratitude. The ceaseless efforts of Mariya Zheleva and Karthik Dante ensured both industry sponsorship and engagement. Dong Ma handled all aspects of video recording for this conference. Robert LiKamWa infused creativity and enthusiasm into the role of Community Engagement Chair. Atul Ingle, Ameeta Agrawal and Banafsheh Rekabdar coordinated a set of fun social events. Our web chairs, Samuel Shippey and Yejun Yang devoted many hours of effort to ensure that the conference website was always up to date.

We are thrilled to welcome over a hundred students to this conference. A perhaps unprecedented number of 60 students received financial support for attending the conference, due to the commitment and diligence of our student travel grants chairs, Bhuvana Krishnaswamy, Ana Aguiar and JeongGil Ko.

A conference of this magnitude would not be possible without financial support from our sponsors and supporters, including NSF, ACM, SIGMOBILE, Portland State University, Microsoft, Juniper Networks, Cambridge Mobile Telematics, Google, Earable, and Cisco. In particular, at Portland State University, we are much obliged to Mark Jones, the computer science department chair and Wu-chi Feng, the Dean of the Maseeh College of Engineering and Sciences, for their generous institutional support of the conference.

We are incredibly grateful to the MobiSys steering committee, led by Victor Bahl and Lin Zhong, for entrusting us with this conference. We are indebted to David Kotz and Junehwa Song for sharing their invaluable experience as past general chairs and guiding us on running a smooth conference. Lili Qiu and Jennifer Chen at SIGMOBILE, and John Otero and April Mosqus at ACM provided ample logistical support in organizing the conference.

Last but not the least, we thank you, the authors and attendees, for enthusiastically embracing this in person conference. We hope the conference provides a forum for lively discussions, fosters new collaborative partnerships and engenders inspiration for future research endeavors.

ACM MobiSys 2022 General Chair

Nirupama Bulusu
Portland State University

ACM MobiSys 2022 Vice-General Chair and Treasurer

Ehsan Aryafar
Portland State University

MobiSys 2022
Welcome Message from the Program Committee Chairs

We are pleased to welcome you to the 20th ACM International Conference on Mobile Systems, Applications, and Services (MobiSys 2022). We are especially excited to welcome you all to the in-person conference in Portland, OR, USA, after meeting virtually for the past two years due to the COVID pandemic.

ACM MobiSys has, through the years, been the leading venue for research in design, implementation, and evaluation of mobile systems and computing. We aimed to continue this excellence by putting together a strong program with the help of program committee (PC) members with high expertise in the area.

We had 176 submissions out of which 38 papers were selected for publication and presentation, yielding an acceptance rate of around 21%. The submitted papers underwent a rigorous multistage review process. In the first round, each paper was assigned three reviewers. After the first round reviews, 89 papers were selected to move to the second round. These papers were reviewed by two or more additional committee members, followed by an online discussion phase. Then the PC held an extensive discussion and selected 38 papers that were conditionally accepted. The PC meeting was held in a hybrid format that included both in-person and online participation. Finally, each of the conditionally-accepted papers was assigned a shepherd, who guided the authors to produce the final manuscript. All shepherded papers were ultimately accepted.

The resulting program covers an exciting set of topics including underwater robots, acoustics, machine learning, and IoT. We believe that the diversity and quality of these papers reflect the vibrant MobiSys community and cutting-edge research in mobile computing systems.

This year we continued the artifact evaluation program. Submissions with conditional acceptance could opt in for the program, and a separate committee was formed for the evaluation. 13 papers applied for the program, and the committee closely examined the provided materials and awarded 11 papers one or more Artifact Evaluated badges.

We sincerely thank the 41 program committee members for their dedication and effort in reviewing the papers and guiding the papers through the shepherding process. This is an astounding amount of work and we are truly humbled by the time and effort devoted to this voluntary, yet crucial, work for our community. Special thanks to Inseok Hwang and Nirupam Roy, the artifact evaluation chairs, for their tremendous work in evaluating the artifacts.

Putting together the program for ACM MobiSys 2022 was a team effort. We express our deepest gratitude to Nirupama Bulusu, the General Chair, and Ehsan Aryafar, the vice General Chair, for organizing the team. We thank the organizing committee members as well as ACM and SIGMOBILE for all the arrangements that made this program possible.

We hope that you find this program interesting and thought-provoking. We also hope that the conference will provide you with a valuable opportunity to share ideas with researchers and practitioners around the world.

ACM MobiSys 2022 Program Committee Co-Chairs

Aruna Balasubramanian
Stony Brook University

Junehwa Song
Korea Advanced Institute of Science and Technology

Contents

Everything wireless

Better than it sounds

Learning on the device

Tracking the wave

MobiSys 2022 Organization

General Chair	**Nirupama Bulusu,** *Portland State University*
Vice General Chair and Treasurer	**Ehsan Aryafar,** *Portland State University*
Program Chairs	**Aruna Balasubramanian,** *Stony Brook University* **Junehwa Song,** *KAIST*
Local Arrangements Chair	**Wu-chang Feng,** *Portland State University*
Publicity Chairs	**Jun Han,** *Yonsei University* **Marco Fiore,** *IMDEA Networks* **Swarun Kumar,** *Carnegie Mellon University*
Publications Chairs	**Wen Hu,** *University of New South Wales* **Yuan He,** *Tsinghua University*
Posters Chairs	**Jiasi Chen,** *UC Riverside* **Marco Mezzavilla,** *New York University*
IoT Day Chair	**Tarek Abdelzaher,** *University of Illinois*
Workshop Chair	**VP Nguyen,** *University of Texas Arlington*
Registration Chair	**Ashwin Ashok**, *Georgia State University*
Student Travel Grants Chairs	**Ana Aguiar,** *University of Porto* **Bhuvana Krishnaswamy,** *University of Wisconsin* **JeongGil Ko,** *Yonsei University*
Demo Chairs	**Sanjib Sur,** *University of South Carolina* **Yasaman Ghasempour,** *Princeton University*
Sponsorship Chairs	**Karthik Dantu,** *University at Buffalo* **Mariya Zheleva,** *University at Albany*
Community Engagement Chairs	**Dilip Sundarraj,** *Juniper Networks* **Robert LiKamWa,** *Arizona State University*

Videos Chair	**Dong Ma,** *Singapore Management University*
Mentorship Chair	**Carlee Joe-Wong,** *Carnegie Mellon University*
Artifact Evaluation Chairs	**Inseok Hwang,** *Pohang University of Science and Technology (POSTECH)* **Nirupam Roy,** *University of Maryland College Park*
PhD Forum Chair	**David Burnett,** *Portland State University*
Web Chairs	**Sam Shippey,** *Portland State University* **Yejun Yang,** *KAIST*
Social Events Chairs	**Ameeta Agrawal,** *Portland State University* **Atul Ingle,** *Portland State University* **Banafsheh Rekabdar,** *Portland State University*
Technical Program Committee	**Aaron Schulman,** *UC San Diego* **Alastair Beresford,** *Cambridge University* **Alec Wolman,** *Microsoft* **Ardalan Amiri Sani,** *UC Irvine* **Ashutosh Dhekne,** *Georgia Institute of Technology* **Ben Greenstein,** *Google* **Chenren Xu,** *Peking University* **Chulhong Min,** *Nokia Bell Labs* **Deepak Vasisht,** *University of Illinois at Urbana-Champaign & Microsoft* **Diego Perino,** *Telefonica Research* **Eric Rozner,** *Facebook & University of Colorado Boulder* **Fadel Adib,** *Massachusetts Institute of Technology* **Heather Zheng,** *University of Chicago* **Ilias Leontiadis,** *Meta* **Inseok Hwang,** *POSTECH* **Jeremy Andrus,** *Apple* **Jeremy Gummeson,** *University of Massachusetts Amherst* **Kamin Whitehouse,** *Amazon* **Kasthuri Jayarajah,** *University of Maryland, Baltimore County* **Kate Lin,** *National Chiao Tung University* **Kyunghan Lee,** *Seoul National University* **Lin Zhong,** *Yale University*

	Mahadev Satyanarayanan, *Carnegie Mellon University*
	Mary Baker, *HP Inc*
	Matt Welsh, *OctoML*
	Mi Zhang, *Michigan State University*
	Nirupam Roy, *University of Maryland, College Park*
	Prabal Dutta, *UC Berkeley*
	Qin Lv, *University of Colorado Boulder*
	Rajalakshmi Nandakumar, *Cornell Tech*
	Rajesh Balan, *Singapore Management University & Google*
	Rijurekha Sen, *IIT Delhi*
	Robin Kravets, *University of Illinois at Urbana-Champaign*
	Shubham Jain, *Stony Brook University*
	Steven Y. Ko, *Simon Fraser University*
	Tam Vu, *Oxford University*
	Vikram Iyer, *University of Washington*
	Yingying Chen, *Rutgers University*
	Youngki Lee, *Seoul National University*
	Yunxin Liu, *Institute for AI Industry Research (AIR), Tsinghua University*
	Yuvraj Agarwal, *Carnegie Mellon University*
External Reviewer	**Mingmin Zhao,** *University of Pennsylvania*

MobiSys 2022 Sponsors & Supporters

Sponsors:

Corporate Sponsors

Platinum Sponsors:

Portland State
Computer Science

Maseeh College of Engineering
and Computer Science
PORTLAND STATE UNIVERSITY

Gold Sponsors:

Microsoft

JUNIPER
NETWORKS

Silver Sponsors:

Google

Earable

CAMBRIDGE
MOBILE TELEMATICS

Bronze Sponsor:

CISCO