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# MobiCom'18

Proceedings of the 24th Annual International Conference on  
**Mobile Computing and Networking**

*Sponsored by:*

**ACM SIGMOBILE**

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**Rohan Murty (Soroco, USA/India)**

*Technical Program Co-Chairs:*

**Yingying (Jennifer) Chen (WINLAB, Rutgers University, USA)**  
**Kyle Jamieson (Princeton University, USA)**



Association for  
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## **Message from ACM MobiCom 2018 General Co-Chairs**

We are delighted to introduce ACM MobiCom 2018, the Annual International Conference on Mobile Computing and Networking, the twenty-fourth edition in a series of annual conferences sponsored by ACM SIGMOBILE dedicated to addressing the challenges in the areas of mobile computing and wireless and mobile networking. The conference will be held in New Delhi, India from October 29 2018 to November 2 2018. This is the first time that the highly selective and premier conference is coming to India in its 24-year-old history. We are truly grateful to the Steering Committee to bring the conference to India – that has seen unprecedented growth in Information Technology and Mobile Communications in the last decade.

ACM MobiCom 2018 includes four Keynote talks, Athena lecture, Test of Time awards and a Fireside Chat. In addition, the packed five-day conference includes regular paper sessions, eight workshops, panel discussion, research demonstrations, and a poster session that includes the ACM Student Research Competition. The conference will feature the mobile app competition successfully introduced four years ago. Though tutorials are not a part of the main conference, the conference will feature four tutorials on current and exciting topics by eminent experts from the US.

The ACM MobiCom 2018 program boasts of Keynote talks by eminent experts from around the globe. We are extremely fortunate to have an outstanding set of Keynote speakers in ACM MobiCom 2018. It is to be noted that the majority of the Keynote speakers are women scientists and this is unprecedented in the history of the MobiCom conference. The ACM MobiCom 2018 organizing committee would like to sincerely thank the Keynote speakers – Mr. Mukesh Ambani (Reliance Industries Limited, India), Prof. Monica Lam (Stanford University, USA), Prof. Kathleen M. Carley (Carnegie Mellon University, USA), Prof. Peter T. Kirstein (University College London) and Prof. Andrea Goldsmith (Stanford University, USA). We are delighted that Prof. Teresa Meng (Stanford University, USA) is the winner of the SIGMOBILE outstanding contributor award and Prof. Kyle Jamieson (Princeton University, USA) is the winner of the SIGMOBILE RockStar Award. We would like to congratulate the winners of the Test-of-Time award.

We would like to express our sincere thanks to a few eminent individuals who have kindly agreed to inaugurate the ACM MobiCom 2018 conference on the 30th October 2018. We are so grateful to Mr. Ravi Shankar Prasad, Honorable Minister of Information Technology, Government of India, Dr. N. R. Narayana Murthy, co-founder of Infosys, and Mr. Ajay Sawhney, Secretary, Ministry of Electronics & Information Technology, Government of India, for finding time to inaugurate the conference in spite of their extremely busy and demanding schedule.

We are delighted that four eminent researchers have kindly agreed to spare time and offer tutorials in their areas of research. The tutorials are “Chip-to-chip RF Communications and Power Delivery via On-chip Antennas” by Prof. Larry Richard Carley, “Edge Computing with ParaDrop Tutorial” by Prof. Suman Banerjee, “5G: An Evolution Towards a Revolution” by Dr. Karthik Sundaresan and “Dynamic Network Analytics” by Prof. Kathleen M. Carley. The tutorials will be held on Sunday, 28th October 2018, in the campus of the Indian Institute of Technology, New Delhi, close to the venue of the conference.

ACM MobiCom 2018 includes a very exciting panel discussion titled “Hammer & Nail vis-a-vis AI / ML Applications to Networked Systems.” We are grateful to the panel moderator and the panelists for

having accepted our invitation. We would like to express our sincere thanks to Dr. Pravin Bhagwat, Prof. Andrea Goldsmith, Dr. Manish Gupta, Dr. Rajeev Rastogi and Dr. Gautam Shroff.

The ACM MobiCom 2018 organizing committee is composed of a strong mix of industry and academic researchers from around the world. Through their efforts, a strong technical program has been put together for this year's version of the conference. We are extremely thankful to the TPC Co-Chairs – Prof. Yingying (Jennifer) Chen (Rutgers University, USA) and Prof. Kyle Jamieson (Princeton University, USA). Thanks to their efforts, the ACM MobiCom 2018 technical program will include 42 regular papers on diverse and exciting topics in Mobile Communications. We have had the great pleasure of working closely with Jennifer and Kyle on almost all the events of the conference and greatly appreciate their herculean efforts and timely feedback and suggestions.

We would like to express our sincere appreciation to the Workshops Co-Chairs Prof. Archana Misra (SMU, Singapore) and Prof. Nic Lane (University of Oxford and Nokia Bell Labs, UK) for selecting eight workshops on current and important topics. They have put in tremendous time and effort in arriving at the eight workshops, and we are grateful to them for ensuring a strong workshop program.

Four workshops would be held on 29th October 2018, these are: 1st International Workshop on Communication and Computing in Connected Vehicles and Platooning (C3VP) organized by Hrishi Venkataraman (IIT Srinagar, India), Devendra Jalihal (IIT Madras, India), Surya Satyavolu (Sirab Technologies, USA) and Gabriel-Miro Muntean (Dublin City University, Ireland), 13th Workshop on Challenged Networks (CHANTS 2018) organized by Marius Feldmann (Technical University of Dresden, Germany) and Mahbub Hassan (University of New South Wales, Australia), 1st Workshop on Complex Networked Systems for Smart Infrastructure (CNetSys) organized by Prasant Misra (TCS, India) and Giridhar Mandyam (Qualcomm, USA), 2nd ACM Workshop on Millimeter Wave Networks and Sensing Systems (mmNets) organized by Dimitrios Koutsonikolas (University of Buffalo, USA) and Joerg Widmer (IMDEA, Spain).

In addition, four workshops would be held on 2nd November 2018, these are: 1st International Workshop on Future Industrial Communication Networks (FICN) organized by Deepaknath Tandur (ABB, India), Sudip Misra (IIT Kharagpur, India), Barun Kumar Saha (ABB, India) and Juliano Fischer Naves (Federal Institute of Rondônia, Brazil), 12th International Workshop on Wireless Network Testbeds, Experimental evaluation & Characterization (WiNTECH 2018) organized by Swarun Kumar (CMU, USA) and Andres Garcia-Saavedra (NEC Laboratories Europe), Technologies for the Wireless Edge, organized by Nikhil Karamchandani and D. Manjunath (IIT Bombay, India) and Leandros Tassiulas (Yale University, USA) and the 10th Wireless of the Students, by the Students, and for the Students Workshop (S3) organized by Swadhin Pradhan (UT Austin, USA) and Swetank Kumar Saha (University of Buffalo, USA).

We would like to sincerely thank the co-chairs of all the eight workshops for their untiring efforts in ensuring a very strong and exciting technical program. The workshops will include Keynote and invited speakers, paper sessions, and a panel discussion.

We would like to sincerely thank the Posters Co-Chairs Prof. Abhinav Kumar (IIT Hyderabad, India) and Dr. Prasant Misra (TCS Research & Innovation, India). 48 Poster papers have been selected out of a total of 98 submitted Poster papers. Out of the 48 Poster papers, 21 papers have qualified for the next round in the Student Research Competition (SRC). We thank the SRC chair Dr. Giridhar Mandyam (Qualcomm, USA) for chairing the important event. We are also very grateful to Giri for providing the conference bridge for the monthly ACM MobiCom 2018 conference calls.

We would like to sincerely thank the Demo Chair Dr. Amit Kumar Saha (CISCO, India). Thanks to Amit's efforts, ACM MobiCom 2018 will include 21 Demos. The demos were selected from 27 submitted entries and represent a mix of participants from both academia and industry.

Our sincere thanks to the Finance Chair Prof. Vinay Ribeiro (IIT Delhi, India), Publicity Co-Chairs - Vinayak Naik (IIIT Delhi, India), He Wang (Purdue University, USA), Kirill Kogan (IMDEA Networks, Spain), Wen Hu (UNSW, Australia) and Binbin Chen (ADSC, Singapore). We would like to greatly appreciate the efforts of the local arrangements Co-Chairs - Prof. Vivek Bohara (IIIT Delhi, India) and Prof. Rijurekha Sen (IIT Delhi, India). As co-chairs, both of them have put in a lot of effort in logistics and local arrangements. Several of us have been attending monthly meetings at the Le Meridien Hotel in New Delhi in order to ensure that no stone is left unturned in planning for the conference.

Our sincere thanks to the Social-media Chair Yuanjie Li (UCLA, USA), Mobile App Competition Chair Prof. Robert Likamwa (ASU, USA) and Dr. Sayandeept Sen (IBM Research, India), App Co-Chair Prof. Haitham Hassanieh (UIUC, USA), MobiJob Event Chair Prof. Swarun Kumar (CMU, USA), Student Travel Grants Co-Chairs Prof. Gaurav Kasbekar (IIT Bombay, India) and Prof. Carlee Joe-Wong (Carnegie Mellon University, USA).

We would like to sincerely thank the ACM MobiCom 2018 Advisory Committee that includes Prof. Anurag Kumar (IISc Bangalore, India), Prof. Uday Desai (IIT Hyderabad, India), Prof. Huzur Saran (IIT Delhi, India), Prof. Krithi Ramamritham (IIT Bombay, India) and Mr. B. M. Baveja (Former Senior Director, MeitY, Govt. of India). Their advice and feedback were important in ensuring a rich and high-quality conference program. Our sincere thanks to the MobiCom 2018 Steering Committee members - Dr. Victor Bahl (Chair) (Microsoft Research, USA), Prof. Suman Banerjee (University of Wisconsin-Madison, USA), Prof. Ramesh Govindan (University of Southern California, USA), Prof. David B. Johnson (Rice University, USA), Prof. Kang Shin (University of Michigan, USA) and Prof. Heather Zheng (University of Chicago, USA). Several members of the steering committee have attended the monthly conference calls and have provided detailed feedback on the progress and planning of the conference.

Though we are grateful to the entire organizing committee for ensuring a high-quality, packed 5-day conference program, select members of the organizing committee deserve a very special mention, and we truly appreciate their contributions - they are Rohit Verma, Chandrika Sridhar, Longfei Shangguan, Yan Wang, Vinay Ribeiro and Swarun Kumar. Rohit Verma (IIT Kharagpur, India) has been outstanding as the web chair of ACM MobiCom 2018. He has been a role model and has spent an enormous amount of time and energy in ensuring an excellent and up-to-date web site. The publication Co-Chairs Longfei Shangguan (Princeton & MSR, USA) and Yan Wang (SUNY Binghamton, USA) have worked closely with several organizing committee members, ACM and Sheridan Printing Services in order to ensure that the ACM MobiCom 2018 Proceedings are correct and timely. We would like to thank Ms. Chandrika Sridhar (IISc Bangalore, India) for her support of the conference as the registration chair. She has performed her duties ably and sincerely and has replied to each and every email related to registration and VISA processing. We have had the pleasure of working closely with Prof. Vinay Ribeiro (IIT Delhi, India) on the conference budget. Vinay has spent a lot of time arriving at the detailed budget of the conference. We are also grateful to Prof. Swarun Kumar (CMU, USA) for all his help throughout the year.

The conference is extremely grateful to the industrial sponsors and not-for-profit organizations. ACM MobiCom 2018 is supported by several sponsors. Our sincere thanks go to SIGMOBILE and NSF for providing generous financial support including travel grants for students attending the conference.

We give a special thanks to this year's Gold Sponsor, Infosys. Thanks to Infosys' generous sponsorship of the conference that ACM MobiCom 2018 is able to support students and faculty members from Asia. We are grateful to our Silver Sponsors – CISCO, Google, and Microsoft. Special thanks to the Murthy Foundation and COMSNETS Association for providing generous grants that have enabled students and faculty in Asia to avail of discounted registration fees. We are also extremely grateful to Dr. Pravin Bhagwat and his team at Mojo Networks for providing WiFi services for the conference. We are grateful to VideoKen for being the content partner of the conference. The conference is supported by the Ministry of Electronics and Information Technology (MeitY), Government of India. We are extremely grateful to Mr. A. K. Balani and Mr. B. M. Baveja in MeitY, GoI for their advice and support related to the conference. Our special thanks to the friends and well-wishers of ACM MobiCom 2018. Sudipta Maitra deserves a special mention. He has very ably assisted the organizing committee and has provided very useful feedback and suggestions on the local arrangements and logistics related to the conference.

We appreciate the support received from the management and staff of the Le Meridien Hotel, New Delhi for providing top-notch facilities for the ACM MobiCom 2018 conference. Face-to-face monthly meetings with the hotel staff have helped immensely in finalizing the hotel arrangements.

Our most sincere appreciation goes to Lisa M. Tolles and her colleagues in Sheridan Communications, USA for her untiring efforts in ensuring timely ACM MobiCom 2018 proceedings.

No conference can be successful without the energy and enthusiasm of the volunteers. We are thankful to the 14 volunteers of ACM MobiCom 2018 who have signed up for the 5-day conference. We will hand over the conference to the volunteers on the 28th October 2018 and are confident that their execution will be flawless.

We welcome you to the very special edition of ACM MobiCom 2018 in New Delhi, India, and hope that you are able to take full advantage of all this conference has to offer. We welcome all the Keynote and Invited speakers, organizing committee members and delegates to New Delhi and sincerely hope that you are able to spare some time to see the majestic and historical sites in the capital of India!



**Rohan Murty**  
*MobiCom'18 General Chair*  
Soroco  
USA/India



**Rajeev Shorey**  
*MobiCom'18 General Chair*  
TCS Innovation Labs  
India

## Technical Program Committee Chairs' Welcome

The 24th Annual International Conference on Mobile Computing and Networking (ACM MobiCom 2018) is the premier international forum for disseminating significant, cutting-edge research in mobile systems and wireless networks. The technical program this year features 42 outstanding papers that cover a wide variety of topics including augmented reality, cellular networks, millimeter-wave networking, security, and localization. The program this year also includes an experience-track paper and a verification-track paper, reflecting contributions that present experiences in the deployment and operations of mobile systems and networks as well as contributions that seek to verify and/or characterize recent results using rigorous experimental methodology.

This year's call for papers attracted 187 qualified submissions from across the globe that were carefully reviewed by 63 Program Committee (PC) members along with a selected group of 12 External Review Committee (ERC) experts. The PC was formed with the goal of covering diverse research expertise as well as diverse perspectives and approaches, and included researchers from 12 countries including China, France, Germany, Great Britain, India, Singapore, South Korea, Spain, Switzerland, and the United States. 18% of the PC members were female and there was broad industry participation with PC and ERC members from Alcatel-Lucent, Google, IBM, Microsoft, NEC, and Telefonica. The PC this year was "all-heavy," meaning that all members participated throughout the entire review and shepherding process.

The paper review process was double-blind (both authors' and reviewers' identities were hidden from each other), and carried out in five phases: three review rounds, followed by an online discussion phase, and discussion at the PC meeting itself. In Round 1, each paper was reviewed by at least *four* PC members, with the top 122 papers selected for promotion to Round 2. In Round 2, each paper was reviewed by three more reviewers, with the top 92 papers selected for promotion to Round 3. Round 3 papers received between one and four further reviews, at the chairs' discretion, depending on the strength of their review scores as well as the confidence of those review scores. We are pleased to report evidence that the additional number of reviews helped the reliability of the review process: 15 papers had three Round 1 reviews all scoring either 1 or 2 (out of 4), yet eventually made it into Round 3 on the basis of a fourth first-round review score of 3 or above, and further high second-round scores.

After Round 3, reviewers participated in an online discussion phase to come to an agreement on whether to promote each paper to discussion at the in-person PC meeting, based on an often-extensive technical exchange of each paper's merits and demerits. The online discussion phase resulted in 69 papers being promoted to discussion at the PC meeting, which was held on May 21-22 at Rutgers University in New Jersey. These 69 papers were organized by topic area, and discussed at length in the meeting. After the in-person PC meeting, 42 papers were selected to enter a new doubly-anonymous shepherding process, which we describe next.

The goal of the shepherding process was to maximize the quality of the papers appearing in the MobiCom proceedings through multiple interactions between the authors and the shepherd, informed by the issues that the reviewers flagged in their reviews. To this end, the identity of the shepherd (and reviewers) was hidden from the authors, and vice-versa. Paper reviewers also had input to the process for papers they have reviewed, via direct communication with the shepherd (but not the authors). The final decision on a paper's acceptance for presentation and publication at MobiCom 2018 was made by agreement between the PC chairs and the anonymous shepherd, taking into account input from paper reviewers. The end result is an exciting technical program composed of 42 very high quality papers.

Putting together the *MobiCom* ‘18 technical program was a team effort. We first thank the authors for providing the content of the program. We are grateful to the PC, who worked very hard in reviewing papers and providing feedback for authors. We also want to thank the entire *MobiCom* ‘18 team, especially our General Chairs Rohan Murty and Rajeev Shorey, for their tremendous support and behind-the-scenes efforts. Finally, we extend our thanks and appreciation to the *MobiCom* Steering Committee for their guidance and wisdom.

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

**Yingying (Jennifer) Chen**

*MobiCom* ‘18 TPC Co-Chair

*Rutgers University, USA*

**Kyle Jamieson**

*MobiCom* ‘18 TPC Co-Chair

*Princeton University, USA*

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