The 14th ACM International Conference on Mobile Systems, Applications, and Services (MobiSys 2016) took place from 23–30 June in Singapore and was co-located with the first Asian Students Symposium on Emerging Technologies (ASSET). This year’s MobiSys attracted 351 attendees and featured 31 papers, 20 posters, 35 demos, and 8 workshops, including the first MobiSys Women’s Workshop.

This year’s MobiSys was one of a number of conferences helping to recognize SIGMOBILE’s inaugural Test-of-Time awards for papers that have had a sustained and significant impact in the SIGMOBILE community over at least a decade. Two presentation sessions were held in which Mahadev Satyanarayanan (“Disconnected Operation in the Coda File System”), Roy Want and Andy Hopper (“The Active Badge Location System”), and Victor Bahl and Venkata N. Padmanabhan (“RADAR: An In-Building RF-Based User Location and Tracking System”) gave interesting insights into the story behind their awarded publications, and about the impact of their work in the research community.

**KEYNOTES**

Ravi Jain, Chief Technology Officer at Vulcan Inc., opened MobiSys by describing how we can use modern technology to address complex challenges and ultimately make the world a better place. With case studies ranging from counting elephants using drones for wildlife preservation, to understanding the marine ecosystem, to preventing viruses from spreading around the world, Jain showed concrete and impressive examples of exploiting technology for these use cases. He also discussed lessons learned, such as the importance of creating simple solutions and cooperating with local collaborators for training.

Peeyush Ranjan, Chief Technology Officer at Flipkart, opened the second day of MobiSys with a keynote giving insightful information on technical challenges and opportunities that companies such as Flipkart are facing in developing market like India. The majority of the population has little access to the Internet, mostly limited by cost and bandwidth of mobile data, combined with low household incomes. This creates “leapfrogging opportunities” for innovative technical solutions that can overcome such limitations and be applicable for other parts of the world.

**CONFERENCE SESSIONS**

The papers of the eight conference sessions spanned a range of themes and domains, with privacy and security clearly emerging as an important topic—though the Best Paper was awarded to a paper focused on autonomous control of drones.

**Smart Environments**

The first session was chaired by Eduardo Cuervo (Microsoft Research) and focused on supporting systems for smart environments in domestic spaces and at scale.

Rajesh Balan opened the session by discussing LiveLabs, a large-scale mobile sensing platform developed at Singapore Management University and deployed in multiple locations, including the conference convention center. Balan described the challenges in creating and deploying a production-ready system to support research while simultaneously providing benefits to stakeholders.

Focusing on the re-identification of people, Tobias Grosse-Puppendahl (Microsoft Research) presented a paper on Platypus, a system that re-identifies people by measuring changes in their electric potential through sensors deployed in the floor. Although constrained to room-level localizations, Platypus has proven to identify people with an accuracy of over 90 percent.

Next, Longfei Shangguan (Princeton) presented “The Design and Implementation of a Mobile RFID Tag Sorting Robot.” The MobiTagbot sorting robot can operate in very narrow spaces densely populated with RFID
tags, such as libraries or supermarkets, and detect the exact spatial order of tagged objects. Targeting smart homes and Internet of Things (IoT) deployments designed to measure daily life activities, Palanivel Kodeswaran (IBM Research) presented a system for sensor-failure detection, called Idea. Assuming multiple sensors are deployed for detecting the same activity, Idea can predict the impact of a failing sensor with regard to a reliable activity detection and identifies deployments requiring maintenance.

Frontiers in Sensing

The second conference session was chaired by David Kotz (Dartmouth College) and opened with Romit Roy Choudhury’s “Listening through a Vibration Motor,” a work together with student Nirupam Roy (University of Illinois at Urbana Champaign). The paper demonstrates how a device’s vibration sensor could be used as a proxy sound sensor with high accuracy—offering new capabilities for compact devices that don’t traditionally include a microphone (such as activity-tracking wristbands) but also introducing security concerns for devices not currently considered to be capable of “eavesdropping.”

Next up, Tianxing Li presented “Practical Human Sensing in the Light,” discussing Dartmouth’s StarLight system, which provides environmental monitoring of human activity using only low-cost LED panels and light sensors. Detection of blocked light allows skeletal reconstruction for a moving human. StarLight could enhance existing activity tracking and provide a new approach for whole-body interaction (for example, in virtual-reality systems).

Another opportunity for motion tracking was presented by Sheng Shen (University of Illinois at Urbana-Champaign). Shen and his colleagues’ ArmTrak system uses a smartphone to track the 3D posture of the user’s arm (such as for gesture-based systems). Similarly, the final paper, “BodyScan: Enabling Radio-Based Sensing on Wearable Devices for Contactless Activity and Vital Sign Monitoring,” discusses using wearables as a means of sensing human activity. This joint work between Michigan State University and Bell Labs was presented by Biyi Fang and uses radio to detect a range of activities, including fine-grained biological behaviors such as breathing.

Next-Generation Mobile OS

The final session of the first day was chaired by Jason Flinn (University of Michigan). Amit Levy (Stanford) began with “Beetle: Flexible communication for Bluetooth Low Energy.” Beetle provides an operating system service that uses the Generic Attribute (GATT) protocol to overcome current constraints on applications accessing Bluetooth.

Low Energy peripherals—such as to allow simultaneous access by multiple applications or enforce specific security policies.

Haichen Shen (University of Washington) presented his team’s joint work with Microsoft Research, “MCDNN: An Approximation-Based Execution Framework for Deep Stream Processing under Resource Constraint.” The paper addresses deep neural network execution on resource-poor devices—their runtime framework schedules a catalog of model variants across the device and cloud to maximize accuracy within the resource bounds.

Resource poverty was also a key consideration in “TaskFolder: Dynamic and Fine-Grained Workload Consolidation for Mobile Devices,” by Yuyang Du and his colleagues at Intel. Their observation that equal sharing of workload across CPU cores didn’t transfer well into the Android platform led to an alternative approach that schedules tasks only to the minimum number of cores required to achieve performance, saving up to 48 percent of CPU power.

Although Android and other mobile platforms are now mature enough to have attracted considerable research attention, the final paper, “Understanding the Characteristics of Android Wear OS,” by Renju Liu and Felix Xiaozhu Lin (Purdue) looked to apply this scrutiny to wearable OS platforms. Their paper profiles the behavior of Android Wear to yield a series of lessons.

Transit and Mapping

Tuesday’s first session was chaired by Robin Kravets (University of Illinois) and focused on mapping and transit of locations in mobile systems.

Zidong Yang (Zhejiang University) started the session, presenting how mobility models retrieved from historic bike movement patterns can be used to predict future bike distributions. This approach will help providers improve the (often uneven) distribution of bikes across a network and ultimately increase the user experience.

Next, Gang Wang (UC Santa Barbara) presented security flaws of crowdsourced maps. Wang and his team were able to manipulate Waze at scale by creating virtual vehicles, even allowing them to track movements of other users—jeopardizing user privacy and trust. The work has drawn significant media attention and led Waze to deploy measures against these kinds of attacks.

Crowdsourcing, despite its risks and challenges, is an important mechanism for improving maps. Moustafa Elhamshary (Osaka University) presented the paper, “TransitLabel: A Crowd-Sensing System for Automatic Labeling of Transit Stations Semantics.” TransitLabel automatically detects user activities (such as ticket vending machines or elevators) through smartphone sensors and maps these activities to a crowdsourced indoor map.

In the last talk of the session, Luca Mottola (Polytechnic University
of Milan) described an alternative, reactive-based control approach for autonomous drones in “Reactive Control of Autonomous Drones,” which received the Best Paper award. Instead of constantly reading sensor values and triggering actuators, the authors—Endri Bregu, Nicola Casamassima, Daniel Cantoni, Luca Mottola, and Kamin Whitehouse—propose a “reactive control” mechanism that only triggers controlling components if actual changes in sensor values were observed (which are still constantly monitored). This approach led to an increased control accuracy and improved flight time.

**No More Leaks**
The theme of the fifth session was preventing leaks from mobile phone applications and sensitive user data and was chaired by Ben Greenstein (Google).

Peng Huang (UC San Diego) began the session, presenting DefDroid, a system aiming to prevent poor app behaviors (such as frequent notifications or high data consumption) by constantly monitoring app activities. Unusual behavior is prevented by gently blocking specific actions of the app without breaking its overall functionality.

Next, Paarijaat Aditya (MPI-SWS) presented I-Pic, a mobile image-capture and preference-management application. The app lets anyone specify privacy preferences, which are broadcasted through Bluetooth to other users. I-Pic automatically blurs faces of bystanders captured in the image according to their preferences. When taking images in a corporate setting, apps accessing the camera view can capture potentially sensitive information. Animesh Srivastava (Duke University) presented “What You Mark is What Apps See,” which introduces a system that lets users mark areas (such as faces) that can be captured and accessed by other apps, while hiding other sensible information in real time.

The last talk on Wednesday was held by Saeed Mirzamohammadi (UC Irvine), who introduced Viola, a system addressing the issue of apps accessing sensors in the background without the knowledge of users. It prevents such attacks by monitoring sensor access on a lower system level, and providing trusted notifications to the user. The app itself is secured through constant runtime verification tests to ensure its functionality.

**Better Mobile Interfaces**
The sixth session was chaired by Inseok Hwang (IBM Research) and focused on developing innovative interfaces for mobile devices.

Yu-Chih Tung (University of Michigan) presented the first paper in the session, “Expansion of Human-Phone Interface By Sensing Structure-Borne Sound Propagation.” The proposed software estimates the user-applied force on a smartphone with no force sensor by utilizing the sound transmitted through subtle vibrations of the device body. (For more information, see this issue’s Smartphones department, “ForcePhone: Software Lets Smartphones Sense Touch Force.”)

Kevin Boos (Rice University) presented the next paper, “FlashBack: Immersive Virtual Reality on Mobile Devices via Rendering Memoization.” Because storage is cheaper than graphical computation, FlashBack pre-computes and caches all images that a virtual reality (VR) user might encounter and, at runtime, displays the relevant images from the cache, thus offering full-quality VR experience on weak mobile devices.

The final paper of the session, “uLink: Enabling User-Defined Deep Linking to App Content,” was presented by Oriana Riva (Microsoft Research). Because mobile apps don’t have URLs, it’s difficult to navigate between pages that are part of an app. To address this challenge, uLink lets users bookmark pages inside the mobile app, and, similar to Web bookmarks, these deeply linked pages can be retrieved later.

**Small- and Large-Scale Networking**
This session focused on addressing various challenges in networking and was chaired by Xia Zhou (Dartmouth College).

Frederik Hermans (Uppsala University) presented “Practical Bluetooth Traffic Sniffing: Systems and Privacy Implications,” was presented by Guoliang Xing (Michigan State University). Bluetooth has an adaptive hopping behavior, which makes packet sniffing difficult. The authors show that it’s possible to sniff Bluetooth packets using a dual radio architecture system.

Next, Kaixin Sui (Tsinghua University) presented “Characterizing and Improving WiFi Latency in Large-Scale Operational Networks” showing findings of inadequacy in access-point selection mechanisms in a campus with 47,000 mobile devices. With three practical solutions, the authors reduced latency by half in many devices.

Jingjing Ren (Northeastern University) presented the session’s last paper on ReCon, a system that can reveal smartphone user’s personally identifiable information leaks and allows users to control information that applications can obtain.

**Application Security and Privacy**
The final session of the conference was chaired by Landon Cox (Duke). It began with Long Lu (Stony Brook University) describing joint work with IBM Research in “CASE: Comprehensive Application Security Enforcement on COTS Mobile Devices.” The CASE patching tool provides...
additional security to mobile app (Android) developers for using third-party code. Evaluation shows compatibility with 420 popular Android applications with minimal performance overhead (approximately 5 percent).

Addressing the issue of authentication to mobile devices, Urs Hengartner presented “Targeted Mimicry Attacks on Touch Input Based Implicit Authentication Schemes,” a work completed with his student Hassan Khan and colleague Daniel Vogel (all from the University of Waterloo). Touch input implicit authentication (Touch IA) schemes (relying on finger movement patterns generated during mobile use) have previously been proposed as a useful biometric for authentication. In this work the researchers find that targeted mimicry attacks (as opposed to the random methods usually assumed) can yield very high success rates and thus limit the usefulness of Touch IA for secure authentication.

The next paper, “Privacy Capsules: Preventing Information Leaks by Mobile Apps,” was a joint work from Raul Herbster and Peter Druschel of the Max Planck Institute and Scott DellaTorre and Bobby Bhattarchjee of the University of Maryland. They proposed using Privacy Capsules as a platform for mobile applications that forces execution into two sequential phases: the first allows access to network resources but not sensitive input, while the second gives full access to sensitive input but prevents use of untrusted resources. The authors evaluate Privacy Capsules using a prototype Android implementation.

The final paper of the conference, “Regulating ARM TrustZone Devices in Restricted Spaces,” was a joint piece from Ferdinand Brasser, Christopher Liebchen, and Ahmad-Reza Sadeghi of the Technical University of Darmstadt and Daeyeong Kim, Vinod Ganapathy, and Liviu Iftode of the Rutgers University. Their work looks to address space-specific security concerns (such as restricting data capture) through a check-in process that lets space hosts examine and modify device configuration to prevent unauthorized behavior.

**ASSET**

A three-day Asian Students Symposium on Emerging Technologies was designed to introduce Asian students to various research horizons. Organized as part of MobiSys, it served as a forum to expand their research horizons, peer networks, and professional careers and was attended by 103 students and 10 mentors.

On the first day of the symposium, students were grouped based on research interest and, after attending seminars on scientific writing and presentation, each group was given a topic based on the group’s overall research interest, which they had to present the next day. The first day ended with students presenting a total of 91 research posters.

The second day had four tutorials by four eminent speakers: Nigel Davies spoke about future of digital public displays; Romit Roy Choudhury spoke about the importance of location in context aware services; Suman Banerjee spoke about novel applications and services of edge computing; and Lin Zhong highlighted the importance of the scientific process of system building research. The day also featured one-minute presentations by student groups.

The last day of the symposium started with a presentation by Steve Miller and was followed by a tour of the JTC LaunchPad, which homes multiple incubators, accelerators, and startups. An interactive session with leaders of various startups was organized to explain the process of setting up startups in Singapore. The completion of the LaunchPad tour marked the closing of a successful first ASSET symposium.

This year’s MobiSys conference featured insightful keynotes and a large variety of papers—attracting attendees from all over the world, including North America and Asia. Many scholarships allowed students from developing countries to attend the conference as well, making significant contributions to the community with posters, demos, and interesting discussions.

We’re looking forward to next year’s MobiSys conference, chaired by Tanzeem Choudhury (Cornell) and Steve Ko (University at Buffalo), taking place in the Niagara Falls area in the state of New York.

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