



Report of HotMobile 2010

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The Eleventh International Workshop on Mobile Computing Systems and Applications (HotMobile 2010 www.hotmobile.org/2010) took place February 22 and 23 in Annapolis, Maryland. The workshop is a high-quality forum targeting groundbreaking areas in mobile computing. This year, after a rigorous review and shepherding process, it accepted 15 papers from 61 submissions and attracted 75 attendees from Asia, Europe, and North America. The workshop started with a keynote address by Allison Druin, director of the Human-Computer Interaction Lab (HCIL) and associate professor in the University of Maryland's College of Information Studies, followed by five paper sessions, an interactive panel session, a demo/poster session, and a brainstorming activity. As with previous workshops, it also included a doctoral consortium for PhD students to present their dissertation research work and get early critical feedback from a panel of experts. The workshop's single-track format and small participant size encouraged discussions and interaction between mobile computing practitioners from both academia and industry.

KEYNOTE SPEECH

Allison Druin delivered the keynote, "The Future Users You May Not Be Thinking About: From Older Adults to Children, From the Developing World to the Streets of Chicago," which focused on designing and enabling technology to be accessible by the underserved, elders, and in particular,

children. Toward this goal, Druin's group has employed multidisciplinary researchers working with children aged seven to 11 years to assist in designing new technology. In particular, this research has shown that interactivity shouldn't be limited to certain parts or attributes of the interface, but should instead be a part of the entire system. Further, interruptions are normal for these populations, and the system must gracefully enable users to continue from whatever point at which they left off. Finally, older adults expect immediate results from technology; other-

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wise, they assume they've broken the device and will stop using it, instead of trying again as the younger population is more likely to do.

PRIVACY MATTERS

The first session centered on privacy challenges for location-based services. The first paper, "Preserving Privacy in Location-Based Mobile Social Applications," presented by Krishna Puttaswamy from University of California at Santa Barbara, focused on the challenge of sharing location information on social networks (such as with friends on Facebook) without giving up the information to the social networking

service. The authors proposed sending encrypted data to the servers, where only the users (that is, friends) have the necessary key to decrypt them. Several attendees argued that they would be more comfortable with a large corporation having responsibility of securing their private data, as opposed to users. However, the authors argued that a user-side attack can also occur with centralized systems, so their proposal is no less secure than current server-based solutions.

Wanying Luo from University of Waterloo presented the second paper, "Proving Your Location without Giving Up Your Privacy," which focused on privacy in location proofs. Luo presented six design goals for gathering location proofs proactively while maintaining privacy and anonymity, as well as an architecture for realizing those goals.

URBAN COMPUTING

The second session considered urban computing and presented three papers from Japan, the US, and Finland. Tatsuya Fujisaka (University of Hyogo) delivered his first international talk, "Exploring Urban Characteristics Using the Movement History of Mass Mobile Microbloggers." In this work, Fujisaka and his coauthors collected geotagged and time-stamped microblogs from Twitter; clustered them based on their location information using *K*-Means, a clustering method that partitions the microblogs into *k* clusters; and then proposed two models, aggregation and dispersion, to

CONFERENCES

analyze mass movement patterns in urban areas. The after-talk discussions mainly involved how to choose the value of K in the K -Means clustering method and the limitations of the collected posts, which only included those microblogs with geographical information.

In “A Tale of Two Cities,” Sibren Isaacman (Princeton University) discussed how to explore approximate location information from cellular wireless networks to study human mobility patterns in Los Angeles and New York cities (Long Island and Connecticut weren’t included in the NY area so as to make the size similar and comparable with the LA area). For example, the results identified that Angelenos travel longer daily distances than New Yorkers. Intensive discussions followed regarding the underlying data set. Unfortunately, the authors are unable to release it due to privacy reasons. During the discussion, several participants pointed out that it might be helpful to choose two typical cells in these two cities and then compare mobile user behavior in these cells.

For the last presentation of this session, a winner of a best presentation award, Simo Hosio (University of Oulu) discussed “Supporting Distributed Private and Public User Interface in Urban Environments.” He talked about how to support distributed application user interfaces (UIs) with private UIs for control on personal mobile devices and public UIs on large public screens. He also introduced six example mobile applications running on a large urban computing testbed in downtown Oulu, Finland. In terms of the possible business model, Hosio mentioned that his research group is currently working on the commercial versions of the public display and selling advertisements to local companies.

PANEL SESSION: DO WE TRUST WHAT WE SENSE?

The panel session focused on the issue of trust in participatory sensing. Indeed, privacy concerns and the need

for anonymity can allow a malicious user to generate bogus sensor readings to distort participatory sensing. Two papers in this session presented similar ideas using a Trusted Platform Module (TPM) embedded into the sensor. The first was “Toward Trustworthy Mobile Sensing” from Duke University, University of Washington, and Intel Labs Seattle. The second was “I Am a Sensor, and I Approve This Message” from Microsoft Research. Both compare their methods to prior work by another panel invitee, Akshay Dua. In “Towards Trustworthy Participatory Sensing,” from Portland State University and Commonwealth Scientific and Industrial Research Organization Information & Technology

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Center (CSIRO ICT) in Australia, Dua and colleagues presented a TPM-based solution where a sensor with embedded GPS signs its raw readings, guaranteeing that they can’t be tampered with. Yet, because raw readings are signed, they prevent the system from processing the data, for example, compression.

Most attendee comments focused on the fundamentals of trust and what and who can be trusted. Furthermore, in addition to malicious users, faulty sensors can present bogus readings. While the solutions in this session can address some attacks, a malicious user can still fake analog values and/or the sensor’s physical environment. Fortunately, because participatory sensing applications obtain readings from many users, malicious and faulty users can be detected and/or masked using methods such as voting and reputation management. Yet, solutions such as those presented in this session can increase

attacks’ complexity and improve sensor readings’ validity.

SECURITY—A MOVING TARGET

This session centered on security aspects of mobile systems. Jon Oberheide (University of Michigan) presented “When Mobile Is Harder Than Fixed (and Vice Versa): Demystifying Security Challenges in Mobile Environments.” Oberheide argued for requiring new approaches for mobile device security, noting key differences between mobile and fixed environments when adapting techniques from fixed environments. He presented the key differences in mobile platform, including resource constraints (memory and processing power), mobile-specific attacks, and impact of traditional attacks on mobile devices, with points to be considered for future mobile security research.

Jeffery Bickford (Rutgers University) presented “Rootkits on Smart Phones: Attacks, Implications, and Opportunities.” Rootkits modify the mobile device operating system codes to achieve malicious purposes. The author demonstrated three rootkits: the first overhears a conversation between two parties over GSM; the second sends a user’s GPS location to the attacker’s server; the third runs high-power-consuming applications to drain the battery. Bickford discussed the two common approaches for rootkit detection (hardware assisted and virtual machine [VM] monitoring) and the challenges in adapting them for mobile environments. As more mobile devices come equipped with mobile trust modules (MTM), it’s possible to adapt a hardware-assisted approach to monitor resource utilization and integrity measurement protocols. VM monitoring doesn’t require any hardware support, but the mobile platforms should support VM monitor installation.

Michael Paik (New York University) presented “Stragglers of the Herd Get Eaten: Security Concerns for GSM Mobile Banking Applications.” The

author highlighted the current GSM network security system's weaknesses and noted possible practical attacks on the growing branchless banking applications. The world is moving toward 3G and beyond, and the focus on 2G GSM is limited. Because huge numbers of 2G GSM users in developing countries rely on critical applications such as branchless banking, immediate renewal and standardization of 2G GSM security techniques are necessary. The standard should be publicly available to avoid current variations in implementations. Discussions after the presentation highlighted end-to-end encryption and migration to 3G security standards as possible solutions. However, the migration cost is high, especially in developing countries, as it requires replacing all SIM cards.

CONTEXT AND CONNECTIVITY

This session looked at context and connectivity in mobile computing. Richard Han (University of Colorado at Boulder) discussed "Fusing Mobile, Sensor, and Social Data to Fully Enable Context-Aware Computing." Han suggested that mobile social networks will become an important future research direction for mobile computing. This work proposed SocialFusion, a system that integrates mobile, social, and sensor networks to enhance the various applications' context awareness. SocialFusion's challenges include mining diverse input data streams to provide recommendations to individuals or groups, and preserving security and privacy. For instance, even if a user can protect the individual data stream independently, possible attackers can still infer the correlative privacy due to the system integration. One question that arose from the audience was whether people are willing to use SocialFusion in public; Hosio commented that their study revealed that most of the young people they interviewed don't mind showing to the public their full Facebook profiles. Other participants also pointed out that the language to define

privacy rules, especially for groups, might be another challenging issue.

Jason Hong (Carnegie Mellon University) presented "GurunGo: Coupling Personal Computers and Mobile Devices through Mobile Data Types." To solve the challenges for mobile information access and avoid searching for the same content again on mobile devices, GurunGo can copy potentially useful mobile data types from users' desktops to their mobile device. GurunGo acquires data by either implicitly monitoring users' activities or explicitly letting people copy data from their desktop to their mobile device. The application then annotates and transfers the data. After the talk, Ramón Cáceres (AT&T Labs Research)

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pointed out that many users currently use their mobile phones as their primary computing device, which could limit GurunGo usage. Others mentioned the possibility of copying the data in the reverse direction, from mobile to PC. Finally, Maria Ebling (IBM T.J. Watson Research Center) commented that a better user interface on the mobile phones might be another key issue to explore.

MOBILE APPLICATIONS

This session focused on building and testing mobile applications. Iqbal Mohamed (Microsoft Research) presented "Enabling Mobile Application Mashups with Merlion." The core idea is to use pixel mapping to build a UI for mobile devices based on the UI of a real application running in a real server; this scenario supports remote desktop connectivity (using tools such as VNC servers). The Merlion designer

lets the application developer select and rearrange the components in the visual region of a real application to create a basic layout for the mobile platform. The Merlion runtime in the mobile device connects to the remote server and displays a mobile-specific layout. It also handles the diversity among the devices and platforms (such as screen size, memory, and OS) automatically. The basic mapping between the original and mobile layout is the set of pixels in real layout to the set of pixels in mobile layout. Mohamed also demonstrated how to map a standard Windows calculator and PowerPoint application into a Windows mobile screen.

Ahmad Rahmati (Rice University) talked about "Enabling Pervasive Mobile Applications with the FM Radio Broadcast Data System." RDS (also called RBDS) provides a low-data-rate (approximately 1,000 bps) digital-broadcast channel alongside FM radio. The authors presented a system and related measurements to show that RDS can be used for applications such as participatory sensing, advertisements, enhanced value-added services, and station loyalty promotion. Many mobile devices in the market today are equipped with hardware for receiving RDS; hence the system can be implemented without additional cost or modification to the mobile device hardware.

Jonathan Hull and colleagues (Ricoh Innovations, California Research Center) presented "Mobile Image Recognition: Architectures and Tradeoffs." The authors argued that running the complete image recognition algorithm in the mobile device itself is the most desirable architecture. Using a barcode-reader-like approach, the mobile device camera scans until it recognizes the contents (visual search). Once recognized, it presents relevant digital information about the content. The authors show a sample application, in which a smart phone recognizes a newspaper in an index of daily newspapers. The audience comments focused on server-

CONFERENCES

assisted recognition in which only an index of frequently searched contents is kept in the phone and the rest is housed in the server. This talk won a best presentation award.

DOCTORAL CONSORTIUM

The doctoral consortium provided a platform for PhD students working toward their dissertation to receive feedback and ideas for possible improvements. Bhojan Anand (National University of Singapore) presented his research work on “Konva: Power and Network Aware Framework and Protocols for Multiplayer Mobile Games.” Multiplayer mobile games are a class of application that consumes huge power as they are naturally more computationally intensive and use more hardware components including audio, display, and network to their fullest capacities. Battery lifetime is a key factor that hinders mobile device usability for resource-intensive applications. The Konva framework uses game-application-specific knowledge, acquired through its power-aware game API package and AI techniques, to effectively optimize the power use and bandwidth resources without compromising game experience. Konva also includes a transport protocol, which supports the framework’s power management features and is in tune with multiplayer mobile games’ traffic patterns.

Ahmad Rahmati (Rice University) presented his research on “Context-Driven Energy-Efficient Mobile System Design.” He argued that mobile systems, although benefiting from constantly increasing processing power and a myriad of sensors, take little advantage of their sensors and remain largely blind to their surroundings. Their sensors are, by design and convention, used on demand, for short intervals, and by few applications, and as a result, the system lacks context or information regarding its surroundings. Rahmati presented several examples to show how context awareness

can improve mobile devices’ usability and energy efficiency, including video encoding, wireless interface selection, and the prediction of wireless network conditions. He further presented evidence that smart phone usage is context dependent and proposed using context information for predicting both network and application usage. Context-driven prediction of network and application usage can in turn enable automatic network interface selection for preexisting applications, content prefetching, application preloading, efficient transfer of delay-tolerant data, and better power management.

Bo Han (University of Maryland) presented his research on “Information Dissemination in Mobile Social Networks.” Mobile social networks are viewed as a marriage of traditional social networks and opportunistic networks, in which the local connections are realized through Wi-Fi or Bluetooth ad hoc networks and the remote connections are based on the cellular infrastructure. This dissertation work focuses mainly on target set selection and the Twitter on-the-fly framework. The first problem studies how to choose the initial target set with a small number of users, such that through the propagation among all the users, information service providers can maximize the expected number of users that can finally get the information. Twitter on the fly is a general distributed publish/subscribe framework, with which mobile users can share local knowledge through their phones.

Due to the proliferation of smart phones, mobile operating systems, and online social networking services, mobile systems and applications have increasingly attracted attention in recent years from the research community. HotMobile presents the state-of-the-art research and provides an effective platform to encourage intensive discussions in these areas. Feedback about the workshop also indicates that

the attendees enjoyed the informal and interactive format.

HotMobile 2011 will be held 1–2 March 2011 in Phoenix, Arizona. Anthony Lamarca from Intel Labs will be the general chair, and Landon Cox from Duke University will be the program chair. For more information, please visit www.hotmobile.org/2011. We look forward to meeting you there. ■

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