



What Can the Internet of Things Do for the Citizen? Workshop at Pervasive 2010

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The Internet of Things (IoT) is starting to gain widespread acceptance. Networked objects and items that have the capability to report about their state, location, and conditions are being deployed in production and supply chains. Our lives are also becoming increasingly interlinked through mobile phones, networked appliances, and devices. Held as part of Pervasive 2010, the Citizen Internet of Things 2010 workshop (CIoT 2010: What Can the Internet of Things Do for the Citizen?) consisted of approximately 25 researchers from Europe, Asia, and the US who discussed applications and new challenges in this field. Topics included mobile applications using Twitter and Facebook to facilitate urban interactions, opportunities for user innovation, as well as changing perceptions of privacy.

EMERGING APPLICATIONS AND INTERACTION PARADIGMS

Christof Roduner and colleagues from ETH Zurich presented a browser for things, which would make it easier for product manufacturers to add services to their products. A major challenge in mobile phone development is dealing with the diversity of available platforms. To address this problem, this work proposed BITML (Browser for the Internet of Things Meta-Language), a metalanguage based on the script-

ing language Lua. BITML makes it easier to develop platform- and device-independent services by offering programming abstractions that free developers from dealing with particular tagging technologies (such as RFID or bar codes) and communication technologies (such as Bluetooth or GPRS). Roduner and colleagues showed a prototype browser for the Nokia E61i, along with several examples implementing price comparison, carbon

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footprint information, and allergy advice. There was a consensus among the audience that, just as the development of HTML5 location is becoming part of the Web browser, product information could be next.

Dimitris Ringas and colleagues from Ionian University Corfu discussed the opportunities of using citizens' traditions, customs, beliefs, and individual experiences to create a cultural digital heritage describing places and locations in cities. Locations throughout the city could be marked by bar codes or referenced by geolocation, with a

corresponding media database storing relevant content. The mobile phone could act as a tool to capture and replay content of this so-called urban memory for tourism or education purposes. Several projects, such as storycorps.org, cityofmemory.org, and Urban Tapestries, have demonstrated this concept's feasibility. The workshop participants discussed stationary media-capturing booths as an alternative to mobile phones. Participants also discussed the "Flickr effect," in which too much information for a single location could make user navigation and quality management difficult. User ratings and feedback could be an option here. Finally, participants discussed systems that can also forget content over time.

CASE STUDIES AND EXPERIENCE REPORTS

Irena Pletikosa presented Thingbook, a prototype that links products to Facebook. It's not uncommon these days for people to microblog their thoughts and current activities on social networks. Through a user study, Pletikosa found that people also wanted to show what products they own or intend to buy. Letting people add comments and short reviews about these products offers a new way of instantly accessing friends' product experiences, which might be useful when making a purchase decision. Discussion of this work focused on

the challenge of preserving uniqueness and individualism in contrast to mainstream recommendations of the crowd.

Gerd Kortuem's (Lancaster University) presentation followed up on this discussion by examining the diffusion and adoption of applications that directly benefit users. Based on his observations, ubicomp and pervasive computing researchers have focused much on building application tools and platforms but little on diffusion. He proposed giving ordinary citizens a voice, not just as commentators of ongoing IoT developments, but also as innovators and shapers of technology. As an example, he mentioned smart homes, which are mostly vendor driven and allow little customization for the people using them. There must be better abstractions that empower people without programming skills to develop applications for their needs. Furthermore, incentives for sharing such innovations with other users should be a major goal, establishing a marketplace for user-generated IoT developments.

INFRASTRUCTURE AND NETWORK

Luis Roalter from Technische Universität München showed how to empower physical objects to share pictures, comments, and sensor data via social networks. For example, smart houses might have doors notifying its owners who has been entering, and plants that ask for more water. This talk focused on how to model dependencies among objects and manage them with a rule-based model, which triggered a discussion about the maintenance and authoring of these rules: who sets them, who keeps them consistent, and how to keep the user in control. Whereas direct communication with devices via social networks seemed to be exciting, the workshop participants voiced a general concern about machines flooding social networks with auto-generated information.

In his presentation, Ioannis Krontiris from the University of Mannheim called for open world-sensing applications. In

contrast to the diversity of urban sensing applications for one particular use case, such as those focusing on noise or pollution data, he argued for a more open approach in which users can decide to collect any type of raw sensor data they wish and upload it to a central platform for sharing. Other users could then create custom mash-up applications that combine an emerging variety of data, hopefully fostering more momentum and participation than today's special-purpose applications do.

Marc Roeland (Alcatel-Lucent Bell Labs) introduced the well-known, everyday concept of "do-it-yourself" to IoT to enable more coordinated mass creativity. He claimed that the do-it-yourself approach was an appropri-

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ate way to access the long tail of IoT applications and to justify the fixed deployment costs for sensor and communication infrastructure. In particular, he categorized do-it-yourself activities for IoT into using thing-generated data, connecting things with each other, and composing new devices. He derived three architectural concepts to enable IoT application development: "callouts" that augment the real-world environment with information, "smart composites" that can be used to create physical object mash-ups, and "phenomena-aware applications" that feature filters to act on data. The audience debated about how to reach an "if you can't open it, you don't own it" metaphor for an IoT.

SOCIAL IMPLICATIONS AND CONSEQUENCES

Andrea Girardello (ETH Zurich) challenged the conventional wisdom about privacy when presenting TwiPhone, a mobile app that posts mobile phone

event data, such as time and caller ID, as well as SMS communication, including text contents, to Twitter. According to Girardello, this essentially meaningless application, which seems nightmarish for privacy advocates, has surprisingly been downloaded by several thousand Android users. TwiPhone is also regularly used by several hundred people whose conversations can be publicly retrieved on Twitter using the #twiphone hashtag. Unsurprisingly, this application led to great controversy among the participants. Do users not care about privacy anymore, or are they just unaware? Is privacy becoming an optional feature?

TOOLS ARE NOT ENOUGH

Throughout the workshop, participants were asked to think of issues and aspects relating to citizens and IoT write them on sticky notes. The entire group then organized the notes and clustered them into topics. The resulting clusters were crowd-sourcing, system design, business models, and privacy.

Through this exercise, a consensus among the participants emerged that simply building platforms and tools is not enough. Instead, research should target larger user bases and aim for larger-scale evaluations.

Attendees formed groups to discuss the four cluster topics. The first breakout group investigated the question of how to drive adoption of crowd-sourcing applications. The group identified competition among users as an incentive to participate, with virtual credits or status being one way to foster competition. Application developers can also tag their data with appropriate metadata to facilitate finding useful apps. However, researchers can at best only weakly influence adoption, which is a fundamental risk for research projects relying on crowd-sourcing.

The second breakout group focused on the practical challenges of building sharable applications from a system designer's perspective. The distinction between research and service provision is

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blurred if many people start adopting the application, given increased requirements for uptime and handling of massive amounts of data. Furthermore, the group discussed the role of standards, in terms of whether standards foster or restrict new applications. Finally, it concluded that for effective user participation, the pervasive research community must develop new user-programming and configuration methods, possibly leveraging physical interaction metaphors.

The business model breakout group focused primarily on how to build a reasonable user base—going beyond the inner social circle of colleagues and students next door. Also, instead of looking for a single “killer app,” facilitating several diverse applications could be a more viable path forward. As an open question, the definition of an established methodology for conducting larger-scale remote user studies in social networks was posed.

The last breakout group focused on IoT privacy needs. This group proposed a principle of give-and-take. Privacy-aware applications should let users opt in and give incentives for providing data. Users who share their own data would be granted access to features or services that build on this data, which is also provided by others. Another question was how to empower individuals to share data on a per-need basis without requiring trust in a third party mediating the data exchange. Finally, the discussion elaborated on the limits of privacy users are willing to accept. What are the characteristics of paranoid persona versus open persona? Although there might be cross-cultural differences, the trade-off between giving and taking might be good compromise.

This workshop was the first of its kind focusing on IoT citizens. Previous related workshops, including PTA 2006 (Pervasive Technologies Applied workshop 2006)¹ and PerTec 2007 (Pervasive RFID/Near Field Communication Technology and Applications workshop),² focused on consumer applications based on RFID and near-field

communication (NFC). The discussions clearly showed that although the IoT is starting to reach a tipping point, the analogs to blogs, wikis, and community platforms have yet to be created. During the CIoT 2010 workshop, participants discussed various applications proposing the integration of real-world context into social networks. In addition, they discussed several platforms for lowering the barriers for user innovation in creating IoT applications. Future research should investigate and develop mechanisms and incentives to facilitate not only development but also distribution.

The convergence of tagging technologies, bar code, and RFID readers in mobile phones, location-based services, and data- and application-sharing platforms is starting to popularize the IoT. Augmented reality on personal mobile devices, combined with ubiquitous and networked public displays, is also a key ingredient for accessing the IoT for people outside corporate use cases. Users no longer communicate only with people but also are empowered to interact with objects—the IoT approaches the user.

For more information on the CIoT 2010 workshop, see www.autoidlabs.org/events/ciot2010. The workshop papers were published in *Adjunct Proceedings of Pervasive 2010*.³

REFERENCES

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