Mobile Computing to Support Sustainability

Aharon Abadi
IBM Research – Haifa Israel
aharona@il.ibm.com

Lori Flynn
CERT, Carnegie Mellon University
Pittsburgh, PA USA
lflynn@cert.org

Jeff Gray
University of Alabama
Tuscaloosa, AL USA
gray@cs.ua.edu

Aaron Gordon
Metropolitan State University
Denver, CO USA
aaronjg@mac.com

Abstract

This report documents the Mobile Sustainability activity that was facilitated at the end of the Workshop on Mobile Development Lifecycle (MobileDeLi), in conjunction with SPLASH 2015. The workshop attendees were presented with several discussion questions and were charged with the task of listing the challenges in Mobile Sustainability. Participants were asked to outline a research agenda that could address the core challenges.

Categories and Subject Descriptors D.2.13 [**Reusable Software**]: Domain engineering

General Terms Mobile Sustainability, Mobile Energy, Mobile Software Engineering

Keywords Mobile devices, App Development

1. Activity Introduction

The Mobile Sustainability activity was a 90 minute activity that was facilitated at the end of the Workshop on Mobile Development Lifecycle (MobileDeLi). There were 40 attendees in the workshop across the day and about 30 participants were engaged in this final activity. The main goal was to collaborate on identifying the challenges in mobile sustainability and suggest a research agenda to deal with the significant challenges. The activity encouraged personal reflection, group work, artifacts presentation, and open discussion. The guidelines that were stated before starting the activity encouraged a diversity of opinions to initiate collaboration within the constraints of a time-boxed activity. Lori Flynn introduced the activity, and spoke about how the topic of "Mobile Computing to Support Sustainability" can be considered from several perspective: mobile device energy use, mobile devices used as an integrator for sustainability, and reuse/recycling of mobile devices.

Mobile device energy use is one aspect of sustainability. Device manufacturers and operating system providers compete to provide energy efficient devices, because consumers want their devices to continue to work despite time passing (and possibly device use) since last recharge. For instance, the Android Doze system manages the behavior of all apps running on Android 6.0 or higher, saving power by performing much less background CPU and network activity if it detects that a device has been left unattended for a period of time, by using significant motion detection. Android versions 6.0 and higher also include App Standby, which determines if an app is not being actively used, and then puts the app into standby state until the device is plugged into a power supply or the user activates it [1]. Apple's iOS 9 has a Low Power Mode which can be used to save energy, and iOS 9 devices use light and proximity sensors to determine if the device is laying face down; and then if so, stop the screen from turning on [2]. Solar energy smartphone chargers are marketed for green power [3], and a local or large-scale energy grid could use green power to charge mobile devices, but as yet there is no green power solution built into mobile devices.

Mobile devices can be used to integrate systems and activities supporting sustainability. For instance, mobile devices with GPS are used with mapping applications such as Google Maps (e.g., Mass Transit [4], Bicycling [5], and Walking [6]), for easier mass transit use, and safe bicycling and walking directions. By making these sustainable methods of transportation easy to use, mobile devices support green transportation. Mobile devices are used to support farmers in developing regions, helping them to remotely perform irrigation control and to obtain agriculture pricing information [7]. In these ways, mobile devices support a sustainable economy and food supply. Healthcare support could also be considered as affecting economic and societal sustainability, for instance if one

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considers a death as wasteful of resources a society invests in the individual, and also considering social and economic losses by the other people affected, suffering from the loss of the individual. In remote and/or developing areas of the world, mobile devices enable healthcare information to be conveyed to and from medical experts [7]. Mobile devices also allow real-time health monitoring and mobile apps can even automatically call for help if a healthcare emergency is detected. By preventing deaths and catching health problems early before they become more resource-consuming, mobile devices can support sustainability.

Mobile devices could support sustainability through re-usability. The question was raised, "How reusable/recyclable are current mobile devices?" For sustainability, our mobile device lifecycles could include reuse of parts, or of whole devices. Currently, do-it-yourself-repair of damaged phones is not common, because the knowledge is technically advanced and some of the tools required to do so are uncommon. Perhaps most mobile device users waste resources and throw away devices rather than pay experts to repair them, because users are not able to repair the devices themselves. Many users fail to securely delete sensitive personal information from mobile devices before selling or passing on the device. Others destroy the device rather than pass it on to another user, out of fear the device might still have sensitive information the user does not know how to delete. In order to better support sustainability, mobile devices must aid non-technical users to securely delete sensitive information and to pass on their phone for reuse by others.

The workshop attendees split into three groups. During the activity, each group addressed each of the following discussion topics separately for five minutes. After that, each small group summarized their ideas in a discussion with everyone at the workshop for five minutes. This small-group discussion followed by full-group discussion was repeated three times, for the three discussion topics contained in the following sections.

2. Mobile vs. Non-Mobile

The first discussion question presented to attendees was, "Why are mobile devices so different from non-mobile, with respect to sustainability?" Participants were asked to suggest 2-3 significant differences on the matter of mobile sustainability. The following are the three group responses.

2.1 Group 1

The first group observed that mobile devices are engineered in a way that much of the hardware cannot be replaced, versus computer towers. Mobile batteries are often very bad for the environment, and group members were not sure about the ability to recycle. Beyond batteries, mobile devices have other materials that are bad for the environment. Mobile device resale prices tend to be very cheap and not worth reselling, which discourages recycling and reuse. Further, the cellular network infrastructure is always available to support the devices. Users often tend to leave their mobile devices on, more so than with non-mobile devices. On the other hand, supporting sustainability, one smartphone replaces many physical devices that used to be manufactured separately, including an MP3 player, camera, and video recorder.

One participant asked if heat energy from a body holding a device (e.g., in a pocket or hand) could be used to help power mobile devices, or if kinetic energy transferred to the device (e.g., while walking) could be harnessed. Another participant said it is very hard to generate enough power, because smartphones use a lot of power. However, watches have indeed been developed that use body heat for power [8] and wall-mounted wireless light switches are on the market that are simply powered by kinetic energy [9]. One participant asked why a solar panel could not be incorporated into the phone screen, but another person said phones are usually in a dark pocket, a dark bag, or simply in rooms with no sunlight. As long as sustainable methods (e.g., wind, solar, hydroelectric, geothermal) are used to produce the electricity that powers the phone, the phone itself does not need to generate green energy.

2.2 Group 2

The second group discussed whether the use of mobile devices is less sustainable than not using mobile devices. Many of the talks at this workshop discussed ways of saving energy by, for example, off-loading work to a server. What these talks did not say was that off-loading saved mobile-device energy, not energy overall. The energy used to communicate with the server along with the energy used by the server for calculations is probably more than the energy saved on the mobile-device.

Mobile-devices also use energy just by being on frequently and also use energy surreptitiously, communicating with cell towers, WiFi hubs, Bluetooth devices, satellites for location information, and various servers. The group also felt that users access servers more often for information than they would with more traditional computers. Finally, from a small sample of experiences, it was observed that users currently replace mobile devices more frequently than they replace other computers, thus using more resources for manufacturing and disposal.

On the other hand, the group members did recognize ways mobile devices help users lead a more sustainable life. Perhaps the use of services like Uber and Lyft leads to a decrease in personal automobile use. It also seems that car sharing programs (like Zipcar, and Car2Go) leads to a decrease in personal automobile ownership (families might own one automobile instead of two) which results in fewer automobiles being manufactured and a decrease in infrastructure needs. Similarly, bicycle sharing programs (like B-Cycle) decrease the need for personal bicycles. All of these programs, along with the use of traditional public transportation, are facilitated by the use of mobile apps that help a user find and use a service when and where needed.

The group members came up with two other examples of mobile apps facilitating users saving energy. First, airplane pilots have replaced their paper charts and maps with digital versions stored on tablets. This change saves fuel by reducing weight. Second, the use of crowdsourcing apps like Waze helps drivers spend less time in traffic which should decrease the use of fuel.

2.3 Group 3

One observation made by participants is that mobile computing may often require acquisition of location-aware data from multiple places where people are holding device. This is due to the potential for deep sensor-based connections and data acquisition that may not be possible in standard desktop computing. There is a richer integration potential with other devices when moving to the Internet of Things approach. Participants noted that the improved usability of mobile computing facilitates more frequent use (i.e., easier to open a mobile device than a laptop). This has the potential to lead to a more paperless world beyond what is capable with desktop and laptops, which can address sustainability needs for natural resources.

3. Applications for Sustainability

In the second part of the activity, we asked attendees, "In light of these differences, suggest 2-3 ideas for the most important apps for supporting sustainability." The following are the results reported by the three groups.

3.1 Group 1

One person in this group mentioned Google's Project Ara [10], which is a modular smartphone with replaceable phone parts, which has an exciting potential to greatly support sustainable device reuse and recycling. A limited market pilot is intended for release soon [11].

The group agreed that efficient and safe travel route prediction is a very important application for supporting sustainability. One person mentioned that when Uber came into business, people were surprised to find that traditional cabs got more business, too. It was determined that more people gave up their vehicles, after convenient and inexpensive Uber existed. Mobile devices also enable ride-sharing with real-time on-demand carpooling support.

As more devices become networked, mobile devices might be used for providing feedback used for scheduling higher-power things (e.g., turbines, nuclear plants). Similarly, as the Internet of Things develops, pricing information could be used to schedule when to run appliances and save money and more sustainably spread out loads on power grids. For instance, one participant suggested a Nest thermostat might do spot market analysis. Another participant spoke of real-time electricity pricing information being available in some European countries, and a law in Illinois (USA) requires consumer access to real-time electricity pricing costs [12].

The group thought that improving efficiency of data handling is important. One person mentioned that hardware for the backbone used to be proprietary, but that now, it is all virtual machines running on demand, so it is on-demand infrastructure. Someone wondered if embedding datacenters in cellphone towers could be done, to remove transmission power costs. Another participant mentioned that transmission over LTE is energy-intensive for the mobile devices. One way to make cooling servers more efficient would be to suck in cold air from outside to cool servers, then use to heat homes in cold areas. One participant said that is already done in Germany.

3.2 Group 2

This group discussed apps that could help save energy. Letting users know the energy implications of their decisions could lead to users making choices that use less energy. For example, when a user downloads an e-book, the app could let them know how much less energy they will use than if they bought a physical book that has to be manufactured and transported. Also, users might be told the energy cost of app use like checking Facebook, posting a Tweet or checking email. The user might receive these notifications when installing an app, or when using an app. In addition, a notification might inform the user of a better way (e.g., another app to use or another time of day) to more sustainably accomplish the task at hand.

Three other apps discussed within the second group were a financial app that would allow direct transfer of funds between individuals, saving trips to ATMs or banks; second, an app that allows a shopper to research information on products, thus helping the shopper make decisions without having to go home and drive back to the store to make the purchase (or return what was purchased); third, health apps can help users live healthier lives by eating better and getting proper exercise.

3.3 Group 3

Similar to the discussions in the other two groups, participants in group 3 discussed how mobile computing can help to unite people with common travel patterns for transportation sharing options. Apps could also utilize sensor-based monitoring and location awareness to assist in finding recycling locations or identifying waste reducing options (e.g., matching leftover food to those in need).

The location-aware nature of mobile computing could also assist in neighborhood delivery options to improve mail and courier services that have the potential to cut the carbon footprint. The potential for augmented reality in commercial apps might allow things like virtual visits to the grocery store, where goods are then delivered to community areas to reduce the individual transportation costs in areas with large traffic problems. Additional areas where location-aware benefits could be seen in transportation could be sensor-driven energy optimization, where lights on a less-frequented road could be turned off until approaching cars are nearby.

4. Research Challenges

In the last part of the activity, we asked attendees to select one example app and present specific research challenges.

4.1 Group 1

The first group focused on the Internet of Things and dynamic power pricing. The big challenge they saw was to develop an effective buy-in model, to encourage participation, so it is really an economic research challenge. Other challenges (which may need research) include privacy and legislative issues. The economic model would need to incentivize people, but make sure they do not game the system. Another challenge is developing a mechanism to broadcast the current prices, plus an algorithm so devices don't all schedule for the same cheaper time, overwhelming the (previous) off-peak time and causing thrashing. The goal would be to run home devices in cheaply and load-balance the power grid. One approach has bidders provide acceptable time ranges and prices for their home devices (e.g., dishwasher, laundry, robot cleaners) to run, and algorithms that determine use with some heuristics. One participant mentioned that in Zurich, this already exists, and there is a standardization issue because device vendors use any of 35 protocols. Vendors want to own services and do analytics on the data, not just to route it. The group expressed privacy concerns about sharing usage data with a company. In Germany, there is a program to have home batteries store energy, for use in conjunction with getting energy from the grid at optimal times for distribution.

4.2 Group 2

There are many challenges for an app that provides energy-use feedback. There are problems with accuracy, both the accuracy of measuring energy use and the accuracy of needed information (what kind of car is Uber sending? how smooth is the drive?). We also need to measure the overhead of using the mobile device for the task, type and strength of Internet connection. Most of the discussion focused on ride sharing (like Uber). The information needed to calculate energy use is dynamic. How do you get at this information? Determination of what gets compared is an issue, too. (E.g., compare driving to walking? using public transit? owning and using a personal vehicle?). A lot of data is needed to provide accurate feedback.

4.3 Group 3

Several group members observed that many challenges may not be technical, but behavioral, which can be addressed by finding creative incentives for more sustainable, responsible use of mobile devices. The challenge of privacy and cybersecurity may also be present in the context of addressing sustainability concerns and the location-aware nature of some solutions.

Most of the time on this question the group discussed topics related to disaster recovery, such as how mobile solutions can help delay or prevent damage to the environment and ecosystem, as well as physical infrastructure, during a natural disaster. It was noted by the group that each natural disaster has unique recovery and quick response needs (e.g., earthquake, tornado, hurricane, flood) that can affect the sustainability of a region. An obvious research challenge is how to maintain power and presence of communication during a disaster. Coordination of experts across multiple disciplines is needed in disaster recovery, which can be addressed uniquely by mobile solutions.

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