

URB 06 Smart Power Management on Cellphones

URB 06.1 People

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URB 06.2 Overview

Modern mobile phones are changing from single-purpose devices to multi-functional programmable computers. As a result, a plethora of mobile applications are emerging, many of which may run in the background and collect context information to process locally or upload to a server. Campaignr and AndWellness are two examples of such applications developed at CENS. With the presence of such applications mobile phones cannot rely on long low-power idle states to conserve energy. Therefore, these background applications negatively affect phone battery life and thus users' satisfaction of their phones. Our experiences with two such applications, *Campaignr* and *Nokoscope*, indicate that they reduce the phone battery life to less than 12 hours, and therefore, many users stop running them. This is a major obstacle on wide deployment of Urban Sensing mobile applications. To facilitate wide adoption and deployment of other Urban Sensing applications that run on mobile phones, we started the *Smart Power Management* project to solve the battery problem in a systematic way.

Several efforts have focused on reducing power consumption of individual phone components. However, there is evidence that significant power saving potential lies at the application layer. This potential can be realized by exploiting the intrinsic trade-off between applications' quality of output and their energy consumption [Flinn99, Zeng02]. In general, decreasing *fidelity* leads to lower energy consumption. For example, increasing the GPS sampling interval from 15 seconds to 30 seconds reduces the GPS energy consumption by 50%. The effect on quality of service, however, is application specific.

Previous researches in this area are mostly concerned with laptops. The applications on a mobile phone have an intrinsic priority attached to them that the power management system to be aware of. For example, being able to make calls is always more important than listening to music or taking pictures. Existing systems also do not consider legacy applications that have been designed/implemented prior to the introduction of the new power management system.

We argue that urban sensing applications on smartphones should be able to adapt their operation rate or fidelity based on users' battery life expectations. Users cannot be expected to manage how applications run, or to keep track of the battery [Ravi08]. Therefore, the power management system should monitor the system and plan ahead to meet the user's battery life expectations. Such system capabilities would need to rely on models of: battery life, user's charging behavior, energy consumed by "legacy applications" (e.g., calls), and the energy-performance trade-off of each adaptive application.

The initial goal of the project is to construct these models with acceptable prediction accuracy. With these models, we are implementing a prototype of the power management system and modify *Nokoscope*, the Nokia Research Labs logging tool, to use the prototype. This prototype will be used for initial evaluations and if successful it will be incorporated into current and future urban sensing mobile applications.

URB 06.3 Approach

We pursue an experimental approach. We initially started collecting system information from a few volunteer smartphone users. We are using these traces to find appropriate models and also test their performance in trace-based simulations. The first prototype will use *Nokoscope*, and we will evaluate its performance on Nokia smartphones. Future directions of the project will be determined based on the performance of the first prototype.

URB 06.4 System(s) Description and/or Experiments

In a pilot user study we investigated the feasibility and challenges of constructing the three models for battery life, charging behavior, and legacy application usage. For our pilot study we installed Nokoscope, the Nokia Research Labs logging platform, on six volunteers' N95 smartphones for approximately 30 days each. The subjects used N95s as their primary phones. Nokoscope logged system information: screen inactivity, battery level, and charging status, every 10 seconds. We used the screen inactivity times to infer the length of the users' interactions with their phones. A user's interaction with his/her smartphone is a sign of running an interactive application, which can help us profile legacy application usage.

URB 06.5 Accomplishments

User Interaction Model:

We discovered that our users' interaction times with their smartphones follow a truncated exponential distribution model, with relatively high variance. Figure 1 is a plot of complementary cumulative distribution function of the length of interaction times for one of the users.

We could also find patterns in the length of total phone usage based on the time of the day, but due to high variance it does not seem to be useful as a predicting model. Figure 2 plots the average length of activity vs. each hour of the day for a user. The data is from 30 days. Notice the high variance lines.

Our efforts to find suitable models for other aspects of user interaction times is still in progress.

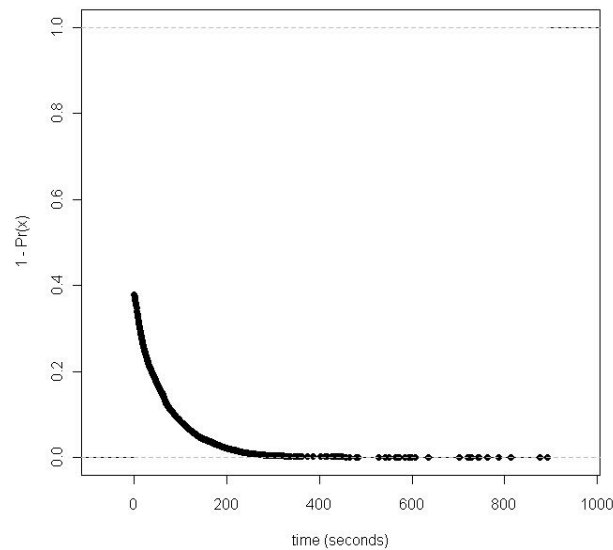


Figure 1. Complementary CDF of the length of interactions with smartphone for one user.

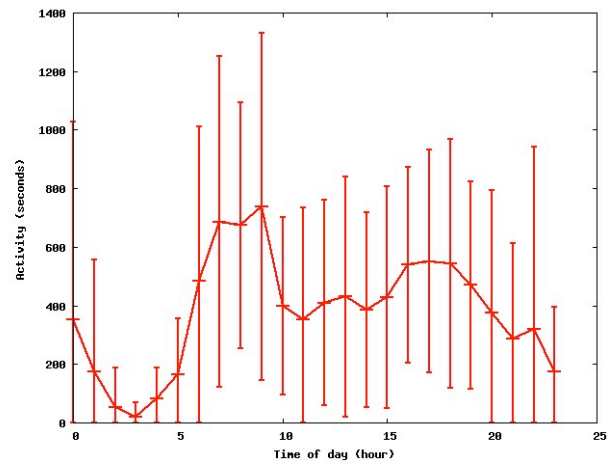


Figure 2: Average length of interaction with smartphone for one user over 30 days.

Charging Model:

Our study shows that individual user's charging patterns are fairly consistent from day to day. For example, Figure 3 is the histogram of the number of times a user charged his/her phone during each hour of the day.

Battery Model:

Unfortunately the Symbian OS does not report accurate battery level information to user applications. Figure 4 is a plot of battery level changes for a user. Note that only eight battery levels are reported by Symbian.

We are trying to find alternative method for battery life models. We are considering off-line energy profiling of different applications.

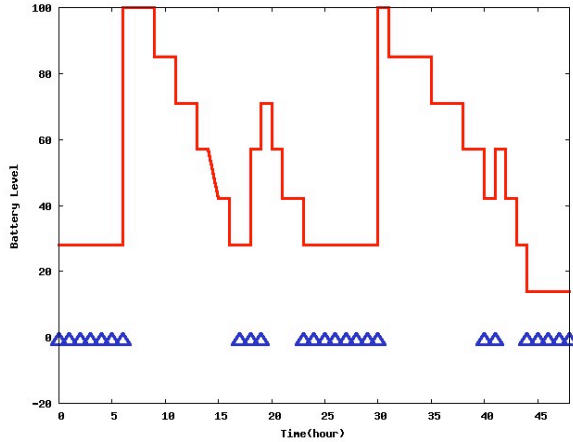


Figure 3: Histogram of the number of charging activities during the day (one user over 30 days)

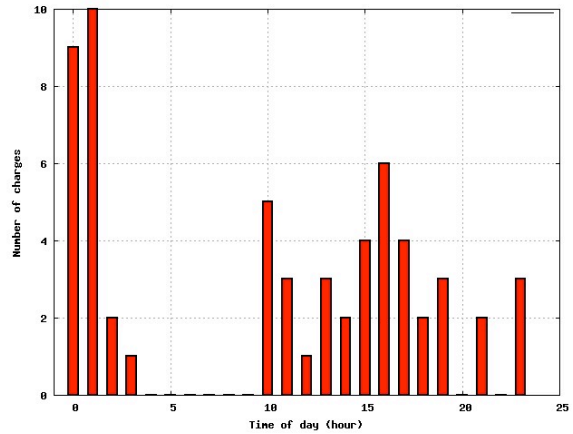


Figure 4: Changes in the battery level during two days for a user.

URB 06.6 Future Directions

We will continue our efforts to build the necessary models. We will consider further user experiments and also novel approaches to model the data.

We will build the first prototype using Nokoscope. We will evaluate the performance of the new power management system in terms of battery life on Nokia smartphones. Future directions of the project will be determined based on the performance of the first prototype.

URB 06.7 External Research Partnerships

Cisco Research (planned)

URB 06.8 References

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