# Challenges of Smarter Power Management on Smartphones


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## 1. INTRODUCTION

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. Such 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.

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. 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.

We argue that pervasive computing 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. 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 tradeoff of each adaptive application.

In this poster we use results from a pilot user study to investigate the feasibility and challenges of constructing the first three models. For our pilot study we installed Nokoscope, the Nokia Research Labs logging platform, on six volunteers' N95 smartphones. 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.

## 2. MODELING CHALLENGES

Figure 1 shows the average length of activity of the same user during each hour of the day for two consecutive periods of 30 days. The error bars indicate high variation. For

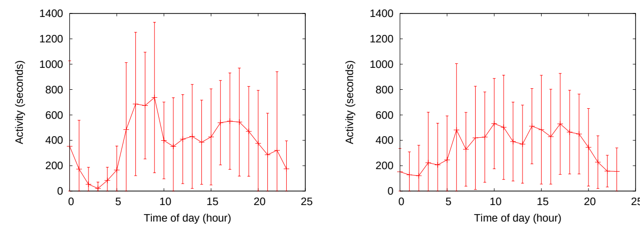


**Figure 1: Length of activity of one user during each hour of the day for two consecutive periods of 30 days.**

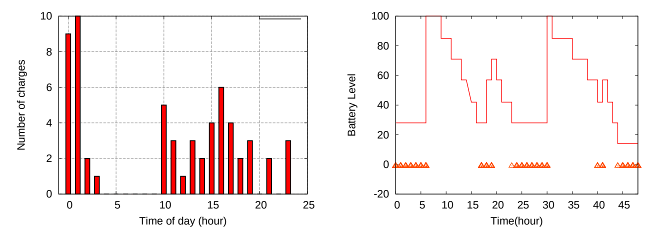


**Figure 2: Histogram of the number of charging events during each hour over 30 days (left) and battery level and charging times during two days (right)**

example the user spends significant time working with the phone at 1am on one day and zero on another day. The shape of the distribution is also different for the left and right plots.

Figure 2 (left) is the histogram of the number of charging events during each hour of the day for 30 days for a subject. Based on this figure, predicting the time when the user will charge the phone, with coarse accuracy, seems feasible. The right plot shows an N95 battery level during two days. The times when the phone is being charged are marked. Unfortunately the Symbian OS does not report battery levels at a high granularity; it only reports eight battery levels.

We encounter the following challenges in constructing the necessary models for smart power management:

- To accurately model users' interaction with their smartphones parameters other than time of the day need to be considered.
- Some phones return fairly granular battery level information. Much more detailed information may be necessary for our system.