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Abstract

As mobile devices become pervasive, it is increasingly important to build mobile systems and applications that adequately address issues such as energy management and disconnected operation. However, there has been little effort to actually understand how these issues impact device usage. In this work, we present the results of a study of 44 laptop computers. We deployed a measurement tool that collects device usage data, including network connectivity and battery usage. Our results indicate that users rarely drain their battery to 0% and that devices are disconnected from the Internet nearly 20% of the time. We believe these findings will have a significant impact on future system design.

1 Overview

There has been a recent increase in the use of mobile devices coupled with pervasive services and applications that are unobtrusive and constantly available. Because mobile devices have limited resources, like energy, they are typically conservative about using pervasive applications. However, we conjecture that resources often go unused. For example, our suspicion is that users recharge their laptop battery with a significant percentage of charge still remaining. The remainder of this paper describes the implementation and results of a study designed to characterize the usage patterns of several laptop users.

2 Implementation

We deployed a Java-based measurement tool that periodically collects the following measurements: the percentage of battery remaining, the charging status of the device, the current CPU usage, the available disk space, a coarse measurement of available network bandwidth, and the duration of time since the last keyboard or mouse input (i.e., idle time). It records this information every 1 to 10 minutes, based on a user-configurable parameter, and reports data collected to a central server. In addition, it only records measurements when the device is in an active or idle state and does not attempt to override its power settings—it does not wake the device from suspension in order to collect measurements.

3 Experimental Setup

In total, the tool has been deployed on 44 laptops, both Windows and Macintosh. It was dis-

tributed in a purely word-of-mouth manner and most of the devices belong to computer science faculty, students, and their friends and families. Though we suspect that the distribution of the user population is highly biased, we believe that these results demonstrate a broad range of usage patterns that can be generalized to the larger population.

4 Results

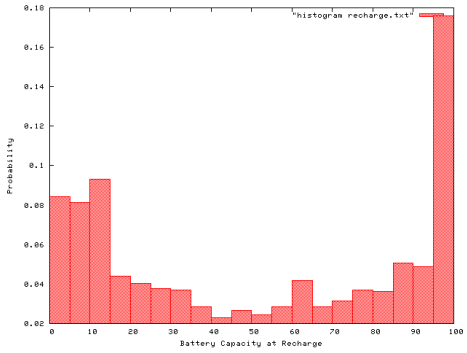

Figure 1: This figure shows the combined probability distribution of the percentage of the battery remaining at recharge for all 44 laptops.

Figure 1 illustrates the probability distribution of the percentage of the battery remaining when a laptop begins to recharge. Unsurprisingly, the percentage of the battery remaining at recharge shows considerable variation. Less than 20% of recharges occur below 10%, while roughly 70% occur at 20% or above. It is somewhat surprising that nearly 18% of recharges occur at 95% or above. We suspect this is the result of two things. First, users often unplug their laptops only for a minute and plug it right back in again. Second, to prolong the battery lifetime, Mac OS X does not continuously charge the battery when plugged in. When the battery drops to 93% or 95%, it will again begin to recharge [1].

Connectivity	Probability
Connected	82%
Not Connected	18%

Table 1: This table shows the probability distribution of network connectivity for all 44 laptops.

Table 1 illustrates that 82% of the measurements recorded by all laptops report the ability to connect to the Internet. Contrary to current speculation that Internet connectivity is nearly pervasive, these results indicate that nearly 20% of the time mobile users are unable to connect to the Internet.

4.1 Discussion

Based on our findings, we have two recommendations for the design of future mobile systems. First, current power management strategies are too conservative. Users exhaust their full battery capacity only a small fraction of the time. We suggest that a user-driven, adaptive strategy for power management would be more appropriate. Second, mobile systems must continue to support disconnected operation. The Internet is not yet pervasive and systems must be able to operate during the nearly 20% of the time that a network is not available.

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References

[1] Apple portable computer's battery does not show a full charge in mac os x. In *http://docs.info.apple.com/article.html?artnum=88344*, 2006.