iSha: A Fine-grained Energy Consumption Analyzer System for Wearable Computing Devices

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1. INTRODUCTION

The variability and complexity of hardware in smart devices has resulted in highly dynamic power variations as opposed to some existing power models with high baseline-power level and small dynamic range [1, 2]. So, the overall system power increasingly depends on highly granular sub-component power measurements. A majority of customer applications utilize Wi-Fi and Bluetooth, both of which have become integral components in most low-power wearable computing and smart devices. While new standards (e.g., 802.11ad) continuously emerge, it provides new opportunities for application and protocol developers to modify existing functionality and improve the user experience in these devices. To that end, we need to develop a new light-weight system to analyze and model the energy consumption patterns of these technologies at a very fine-grained level and be simultaneously applicable for multiple devices. As a result, the developers can directly evaluate and optimize the energy efficiency of their protocols/methods without the need for a power monitor and also bring about energy savings to all applications which use them rather than profiling individual applications.

In this work, we develop a novel and light-weight system, iSha, to insert specific log triggers in the executable code using an assembler/disassembler module. We measure the detailed power consumption patterns of components under different device screen states and generate a model using stochastic approach. We also impart real-world data into the energy model for the developers to emulate "in-the-wild" variations from within their laboratory settings.

2. CHALLENGES AND ONGOING WORK

We start off by measuring the detailed power consumption patterns of Wi-Fi in mobile phones for different screen states (i.e., On, Off) under various Wi-Fi availability conditions (i.e., Good, Poor, Null) and data rates. The current power models do not consider such fine-grained variations, rather only consider the change in baseline power due to overall screen display brightness levels. The energy consumed for some important processes during the Wi-Fi start-up is shown in Table 1. These measurements account for the specific processes alone and do not include the baseline system power. Hence, it captures all the dynamic power variations in the process including tail energy for the series of chipsets. To obtain such measurements in all devices, we have developed a novel prototype script to insert specific log patterns in the Wi-Fi executable using an assembler/disassembler for Android (i.e., smali/backsmali) and hence avoids complex and unnecessary work for the developers to insert log triggers.

Table 1: Fine-grained energy measurements on Nexus One.

Item	Energy (μWh)	
	Screen On	Screen Off
Radio Up	79.90	100.10
Scan	83.40	118.50
Association	77.10	108.00
DHCP	28.90	53.90
Radio Down	39.70	59.40

Although [3] has previously utilized system call tracing for power modeling, it incurs high kernel-level logging overhead (both log memory and energy) as opposed to our approach which is light-weight. The Wi-Fi usage patterns from different devices are logged on to a centralized database and we build an effective energy consumption model suitable for most devices based on logged process events. Thus, we expect to reduce the error from complexity and hidden states. The developers can later obtain logs from a variety of users with various mobility and usage patterns and apply the energy model to evaluate the energy efficiency of their methodologies at various instances and can also emulate "in-the-wild" variations from within the laboratory settings.

3. FUTURE WORK

With more and more chipsets having integrated or combo radios, we will extend our work to other components such as Bluetooth and NFC to obtain a comprehensive energy consumption model for these low power communicating technologies which are more suited for the wearable infotainment devices and the Internet of Things (IoT) architecture.

4. REFERENCES

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