NITOS Mobile Monitoring Solution: Realistic Energy Consumption Profiling of Mobile Devices

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ABSTRACT

The unprecedented penetration of "smart" mobile devices in everyday use case scenarios, along with their energy greedy profile have motivated researchers in the field of wireless networking, towards reducing energy consumption wherever possible. In order to support the design of energy efficient protocols, in-depth energy consumption profiling of mobile devices needs to be applied, through long term monitoring and under realistic conditions. To this aim, we have developed a tiny device able to fit in the battery pack of smartphones and monitor the resulting power consumption in an on-line way. In this work, we detail the components of the developed framework and demonstrate two indicative scenarios that showcase how the diversity of experimental conditions and configurations can significantly impact energy consumption.

1. INTRODUCTION

Prompted by the recent emerging technologies, mobile devices have become increasingly sophisticated, providing high processing capabilities, embedding various hardware components and providing for concurrent execution of multiple software applications. The limited battery life of modern mobile devices, along with their increased energy demands, dictate that design of emerging technologies should be driven be energy related constraints. In order to support the design of energy efficient protocols, in-depth energy consumption profiling of mobile devices needs to be applied, through long term monitoring and under realistic conditions. Among the various existing power monitoring platforms, we distinguish the work in [1] that presents a small-sized device that can be attached to mobile phones. The obtained measurements are directly stored to a microSD card and are manually transferred to a dedicated pc for further analysis. Taking a step further, we introduce the NITOS Mobile Monitoring Solution (MMS) framework that features several more advantages. First, the integration of a bluetooth module that enables transparent communication with the mobile device, allowing for both automatic transferring of obtained measurements and enabling for remote control as well. Second, the development of an accompanying Android application that enables logging of mobile device activity to take place in parallel with the power monitoring procedure, thus allowing for detailed off-line analysis of collected results. In the next section we present the developed framework as an extension of our previous work [2].

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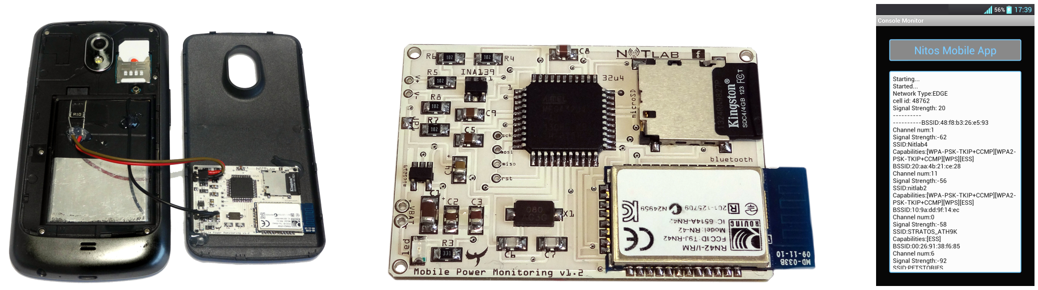
2. NITOS MMS

Towards the development of a small-sized device, we started by designing and a Printed Circuit Board (PCB) that integrates all the required components.The core module is the ATmega32U4 [3], low-power 8-bit micro-controller that runs at 8MHz. It features 32 KB of flash memory and integrates a 12 channel Analog to Digital Converter (ADC), with a resolution of 10-bit. Moreover, the PCB integrates the TI INA139 [4] high-side current monitoring module that is used to amplify the voltage drop on current shunt resistors offering high accuracy of analog sampling. In addition, NITOS MMS is equipped with a microSD slot to enable for external storage and the RN-42 bluetooth[5] module to enable wireless communication with the mobile phone. The total cost of the device is less than €35.

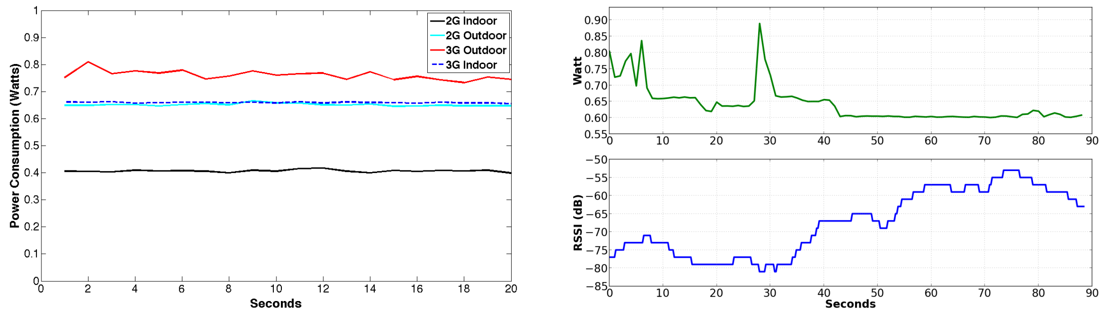
In an effort to render the described hardware platform into a functional framework, we developed appropriate software to control the programming of the MMS platform, by utilizing open-source Arduino code. Aiming at increasing the default sampling rate of 4.33 KHz, to enable for increased sampling accuracy, we properly configured the ATmega32U4 ADC to operate in free-running mode and changed the prescaler from 62.5 KHz to 500 KHz, resulting in the increased sampling rate of approximately 17 KHz. Through this modification, we enable logging of sampled data to take place in parallel with ADC conversions, efficiently increasing the amount of time spent in sample acquisition. By exploiting the RN-42 module, we transfer the collected measurements to the smartphone and provide direct access for further processing and depiction of energy consumption data.

The developed platform has been evaluated in comparison with the high-end NI-6210 data acquisition (DAQ) module [6] and proved of providing measurements of similar accuracy in the range under consideration. Moreover, as the proposed measurement procedure is rather generic, it can be directly applied to most of existing smartphones, since it only requires a minor modification of the battery. As Fig. 1(a) shows, our solution is properly powered by the phone's battery and thus does not require external power



(a) Energy Monitoring Device Integrated with Galaxy Nexus. (b) NITOS Mobile Monitoring Solution. (c) NITOS MMS app.

Figure 1: NITOS MMS Hardware and Software Components.



(a) Average Power Consumption during 2G/3G calls in Outdoor/Indoor Locations. (b) RSSI and Corresponding Power Consumption.

Figure 2: Experimental Results.

supply. Although this design choice does not affect the mobile phone's power consumption, it arises questions related to the impact on the mobile phone's battery lifetime. Due to the low power consumption profile of the various selected components, the proposed device results in a total consumption of 0.043 W and 0.092 W, in idle and monitoring mode accordingly, posing minimal impact on the phone's lifetime.

3. NITOS ANDROID APPLICATION

NITOS MMS application designed and deployed for Android devices, is able to monitor all the information that the Android API exposes, concerning the phone's broadband interface. Each measurement set consists of several variables, such as RSSI, Cell ID, Network Type, Network Operator ID, timestamp and is cached on a local sqlite3 database. To ensure accurate monitoring, the application halts all the unnecessary processes and turns off the non-required interfaces, before triggering the monitoring procedure for both the MMS and mobile phone. Furthermore the application, which is illustrated in Fig. 1(c), exploits any available network connection to off-load the collected data to NITOS [7] server for further processing.

4. EXPERIMENTAL DEMONSTRATION

The prototype device that has been integrated with a Samsung Galaxy Nexus smartphone, as illustrated in Fig. 1(a), will be evaluated under a set of indicative experiments. In the first experiment, we will start by characterising the instantaneous power consumption of the smartphone, during a phone call using the WCDMA 3G interface, while in the second phase we will employ the GSM interface. In Fig. 2(a), we plot the average power consumption, as measured in each different setup and observe higher power consumption for both the 3G and GSM networks in the outdoor environment.

In the second experiment, we will showcase the impact of RSSI fluctuations on the energy consumption of the phone's cellular module. Exploiting the NITOS MMS application, we will collect RSSI measurements alongside with the energy data logging, during a regular phone call. As demonstrated in Fig. 2(b), low RSSI values correspond to higher energy consumption, as it is depicted in the first 40 seconds where the signal ranges from -83 to -68dB.

5. CONCLUSIONS AND FUTURE WORK

In this paper we presented the NITOS MMS that is able to characterise power consumption of mobile devices under real life scenarios. As future work, we seek to integrate the NITOS MMS with mobile phones of volunteers, such as lab members and University students, in order to collect measurements corresponding to the energy that is consumed during long-term execution of everyday life scenarios.

6. ACKNOWLEDGEMENTS

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