Evaluating Energy Consumption on Low-end Smartphones

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Abstract— **The relationship between battery consumption in smartphones and the usage statistics of a phone is direct. Modern smartphones, even low-end, are equipped with multiple wireless technologies, e.g. GSM, 3G, WiFi and Bluetooth. Each of these technologies has a different energy consumption profile. A wireless mesh project in the Mankosi community in rural South Africa is about to introduce low-end smartphones onto the network. The mesh network is powered with solar-charged batteries because the community at present does not have electricity. Local residents also use these batteries to recharge cell phones at a nominal cost. Introduction of smartphones will increase the recharge frequency as phone usage will increase; thus draining a phone battery more quickly, as well as escalate recharge costs. Thus, the smartphones must be chosen and used effectively in order for batteries to last longer. Related work identifies WiFi wireless technology as the most battery efficient way of transfer when compared to GSM, 3G and Bluetooth. This research proposes experiments to further investigate energy efficiency of WiFi in low-end smartphones that we intend to use for local and breakout voice over Internet protocol (VoIP) calls and data services, on a rural wireless mesh network.**

Keywords— ***Limited Range Communications, Ad-hoc, WiFi, Standards, Regulatory & Environmental, Alternative Energy.***

I. INTRODUCTION

The wireless communication technologies in smartphones account for a major component of the total power consumption due to the communication centric usage of these devices [1][2]. The smartphones of today are equipped with multiple radio interfaces such as 3G, GSM, and WiFi; wireless technologies to handle a variety of connections. This implies that energy efficiency of these devices is very important to their usability. Hence, optimal management of power consumption of these devices is critical.

The focus of this research is on the energy consumption by the wireless technologies available on smartphones. The motivation for such research is that an inverse infrastructure wireless mesh project, operational in the Mankosi administrative area of the Eastern Cape Province, South Africa, is considering the introduction of low-end smartphones in the network. At the moment the mesh network offers only voice services [3]. With introduction of smartphones, users will not only be able to call but also chat (WhatsApp), browse Internet, video call (Skype, Viber, and Hangout), and share and stream different types of media (pictures, video and radio). It is likely that with such a workload, a phone's battery will exhaust within hours. Since there is no electricity in the community, the residents recharge cell phones using the excess power generated by solar-charged batteries that power the mesh infrastructure. This service is provided at a nominal cost [4]. Frequent exhaustion of smartphone batteries will also increase the recharge frequency, hence, escalating recharge costs incurred by the users. The project is also considering replacing the older single radio mesh routers called Mesh Potato (MP) with newer ones that have stronger processing power, consist of 802.11n technology and offer dual-radio support. This will increase the transfer rate of the network. Therefore, it is likely that smartphones will run out of battery life faster in a network with newer MPs as usage escalates. Fig. 1 depicts a transition from an older MP with an analogue phone to a newer version with smartphones connected via WiFi. This research paper proposes experiments to investigate energy efficiency of low-end smartphone wireless technologies when used for voice over Internet protocol (VoIP) and data services.

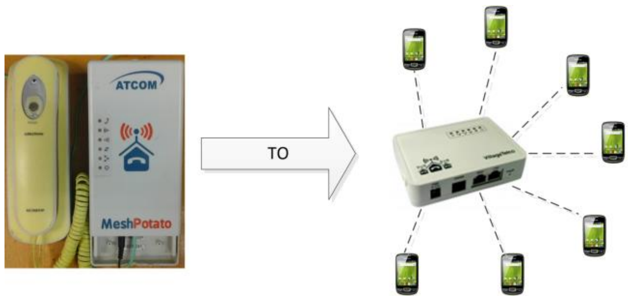

Figure 1: Transition from analogue phones to smartphones over WiFi

II. RELATED WORK

Balasubramanian et al. found that energy consumption is intimately related to the characteristics of the workload and not just the total transfer size, e.g., a few hundred bytes transferred intermittently on 3G can consume more energy than transferring a megabyte in one shot [3]. They compared 3G, GSM and WiFi 802.11b technologies and showed that for a transfer size of 10 KB, WiFi consumed one-sixth of 3G's energy and one-third of GSM's energy once connected to an access point, with efficiency increasing dramatically with increasing data sizes. They also concluded that when the cost of scan and transfer is included, WiFi becomes inefficient for small sized transfers compared to GSM, but still remains more efficient than 3G. Xiao et al. measured energy consumption by 3G and WiFi 802.11g communication technologies when using mobile applications for video streaming [4] and concluded that WiFi is more energy efficient than 3G technology. Friedman et al. measured power and throughput performance of Bluetooth and WiFi 802.11g usage in smartphones [5]. They concluded that the interface selected for data transfer should have minimum P^i_{send} to T_i ratio where P^i_{send} is the power consumed by the interface *i*, when sending data and T_i is interface throughput. Following measurements of power and throughput, Friedman et al. concluded that for all tested smartphones WiFi is always preferable regardless of file size.

These analyses and measurement of energy efficiency of wireless technologies in smartphones have identified WiFi as the most efficient mode of transfer. This leads to the conclusion that we can turn off the 3G on the low-end smartphones in the community and use WiFi for VoIP calls and data services. However, energy consumption by WiFi during VoIP calls (voice and video), chatting, Internet browsing, and media sharing and streaming through different applications (apps) needs to be explored.

III. Proposed Direction

Following the guidelines provided by Molapo and Densmore for selection of smartphones for an ICT4D project [8], and after a market survey, three low-end smartphones were selected: Vodacom Kicka, Vodacom Smart4Mini, and Samsung Galaxy Pocket Neo, costing between R549-R749. Table 1 below compares specifications [9][10][11].

TABLE I
Cell-phone specifications

	Vodacom Kicka [9]	Vodacom Smart4Mini [10]	Samsung Galaxy Pocket Neo [11]
Battery	1400 mAh	1400 mAh	1200 mAh
Wireless technologies	GSM/3G/WiFi 802.11 b/g/n/Bluetooth	GSM/3G/WiFi 802.11 b/g/n/Bluetooth	GSM/3G/WiFi 802.11 b/g/n/Bluetooth
Talk time	8.5 hrs	8 hrs	6 hrs
Stand-by time	403 hrs	600 hrs	600 hrs
Software	Android 4.4	Android 4.2.2	Android 4.1.2
Memory	512 Mb	512 Mb	512 Mb
Processor	1 GHz dual core	1.3 GHz dual core	850 MHz
Cost	R 549	R 749	R 649

For experiments, 60 of these low-end smartphones, 20 of each type, have been purchased. We intend to carry out the following tests:

- Measure stand-by battery consumption of the phones with GSM enabled; WiFi and GSM enabled; and finally WiFi, 3G and GSM enabled; over a 7-day period.
  - Preliminary tests for 6 phones (2 of each kind) over 7 days with GSM enabled only, showed that the 2 Kickas dropped by average 34%, Smart4Minis by 12%, and Samsungs by 42%.
- Conduct internal voice calls using a SIP client.
  - So far, using csipSimple, 24 phones (8 Kickas, 8 Smart4Minis and 8 Samsungs) have been tested for voice calls over 1 hop for 1 hour. The phones were in GSM mode with WiFi on. The experiment was done in 2 sets. Each set had 6 phones (2 of each kind) calling 6 phones simultaneously. The Kickas showed average 22% drop, Smart4Minis 24% drop and Samsungs 17% drop over the 1-hour call duration.
- Conduct internal video calls and measure battery consumption.
  - Currently there is no Android app that offers such a feature, which is presenting us with some difficulties.
- Breakout VoIP video and voice calls using a popular VoIP app.
  - Preliminary testing has been done using 6 phones (2 of each kind) for Google's Hangout voice calls (since it comes pre-installed) for 2 hours. The phones had 3G and mobile data off and were split in 2 sets of 3 phones. Calls were made from one set of phones to another for 1 hour and then vice versa. Kickas, Smart4Minis and Samsungs showed average 27%, 26%, and 25% drop respectively. The drop is almost uniform among all phones.
- Conduct tests to measure battery consumption during media sharing (internal and external) over WiFi.
- Conduct tests to measure battery consumption during media streaming over WiFi.

The battery consumption measurement for preliminary tests has been done using the default Android Battery app. After completion of all tests, the smartphone category that exhibits the best energy efficiency on most tests will be selected. It is hoped that this data can help people make an informed choice towards the selection of a smartphone that best fits their needs.

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