A Signal Adaptation Mechanism for Power Optimization of Wireless Adapters

Christos Bouras, Computer Technology Institute and Press "Diophantus", Patras, Greece & Computer Engineering and Informatics Department, University of Patras, Patras, Greece

Vaggelis Kapoulas, Computer Technology Institute and Press "Diophantus", Patras, Greece & University of Patras, Patras, Greece

Georgios Kioumourtzis, Center for Security Studies, Athens, Greece

Kostas Stamos, TEI of Western Greece, Patras, Greece

Nikos Stahopoulos, Computer Engineering and Informatics Department, University of Patras, Patras, Greece

Nikos Tavoularis, Computer Engineering and Informatics Department, University of Patras, Patras, Greece

ABSTRACT

This manuscript introduces, implements and evaluates a feedback-based adaptation mechanism that adjusts the transmission power of a wireless card on commodity mobile devices. Main focus of this work is to minimize the power consumption by adjusting the transmission power of the wireless card, thus extending the battery life, while negative effects on connection quality are avoided. To achieve that, a mechanism that optimizes the power depending on the quality of the connection is presented, which measures the quality of the transmission and adjusts the transmission power, by utilizing an expanded array of metrics, for more accurate estimation. The mechanism has been implemented and tested on actual wireless adapters. In order to evaluate, fine-tune and improve the mechanism, a list of real environment experiments has been performed. The results indicate that power consumption can be significantly reduced for nodes that are either almost stationary or slowly moving, without any significant increase in packet loss.

Keywords: *Green Networking, RSSI, Signal Adaptation Mechanism, SNR, Wireless Power Management*

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1. INTRODUCTION

As networks and connected devices become more mobile and thus energy constrained, and as the requirements for lower energy consumption become more demanding, the issue of consumed power by wireless network cards is becoming an intensively researched topic. Furthermore, concerns by the public on electromagnetic fields increase the interest of such research. When using a wireless connection, increasing the strength of a signal may result in better quality, as perceived by the end user application, but it also results to more energy consumption and stronger electromagnetic fields. On the other hand, if the signal strength is reduced too much, there is the risk of reduced performance or even losing connectivity completely.

Development of mechanisms that adjust the power consumption to optimal levels is considered necessary (Bornholt, Mytkowicz, & McKinley, 2012). For example, the authors in (Mayo & Ranganathan, 2003) conclude that, in order for single general-purpose mobile devices that combine multiple functionalities to achieve longer battery life, they should be designed to include requirements-aware energy scale-down techniques.

One efficient method to deal with this problem is to optimize the power consumption of network adapters. Research in devices such as smartphones has shown that WiFi adapters are responsible for a significant percentage of the consumed power, and thus energy savings in this area are very important for devices with limited power sources such as battery operated ones (Agarwal, Schurgers, & Gupta, 2005; Carroll & Heiser, 2010; Friedman, Kogan, & Krivolapov, 2011; Malik, 2012; Pering, Raghunathan, & Want, 2005; Rozner, Navda, Ramjee, & Rayanchu, 2010; Shye, Scholbrock, & Memik, 2009). For example, the author in (Malik, 2012) lists WiFi as the most power-consuming mode of an Android phone's functions. Furthermore, research in (Carroll & Heiser, 2010) shows that under specific benchmarks the WiFi adapter can exceed 700mW in power consumption. Similar results have also been verified by measurements on smartphones (Balasubramanian, Balasubramanian, & Venkataramani, 2009) including measurements by end users taken "in the wild" (Shye, Scholbrock, & Memik, 2009).

The IEEE 802.11 standard deals with this problem by defining two modes; the active mode, where the network adapter is awake and can receive data at any time and power save mode. Where it cannot receive or send any data, so the energy consumption is reduced in that state. In (Zheng & Kravets, 2005), an on-demand power management technique is taking advantage of the above, to achieve 50% less energy consumption. In (Kravets & Krishnan, 2000), a transport layer mechanism enables the interface periodically or when necessary, reducing the energy consumption to 17%. However, the above mechanisms are based on active and inactive periods of the interface, which leads to additional delay at the arrival of the frames and degradation of the connection quality.

Another approach to the issue of optimizing power consumption has been made by focusing on other features of state-of-art standards, such as Multiple Input-Multiple Output (MIMO) operation. A mechanism focusing on radio chain management in order to reduce the power consumption has been proposed in (Yu, Zhong, & Sabharwal, 2009), which improved energy efficiency by 32% in best case scenario, with a high data rate (50Mbps). Another work related to MIMO utilization is in (Jang, Hao, Sheth, & Govindan, 2011), where the mechanism introduced, schedules the wake-up and sleep times of the clients, and on top of that, determines the antennas that are going to transmit in a way that is considered the most efficient.

The rest of the paper is organized as follows. Section 2 provides an overview of related work and the contribution of this paper. Section 3 describes the architecture and the mechanisms

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