Chapter 9

An Antiwindup Approach to Power Controller Switching in an Ambient Healthcare Network

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ABSTRACT

This paper proposes a methodology for improved power controller switching in mobile Body Area Networks operating within the ambient healthcare environment. The work extends Anti-windup and Bumpless transfer results to provide a solution to the ambulatory networking problem that ensures sufficient biometric data can always be regenerated at the base station. The solution thereby guarantees satisfactory quality of service for healthcare providers. Compensation is provided for the nonlinear hardware constraints that are a typical feature of the type of network under consideration and graceful performance degradation in the face of hardware output power saturation is demonstrated, thus conserving network energy in an optimal fashion.

1. INTRODUCTION

Ubiquitous or pervasive Body Area Networks (BANs) and their use in the healthcare application space are now beginning to reach a level of maturity wherein a number of innovative solutions are now at advanced stages of commercial development. Several projects, for instance the Complete Ambient Assisted Living Experiment (CAALYX) (Boulos et al., 2007) and Codeblue (Gao et al., 2008), are now actively promoting advances in technology and infrastructure that facilitate independent living, pre-hospital and in-hospital emergency care and disaster response. New hardware technologies, including a number of state of the art sensor node platforms, (e.g.
Tmote, Mica, Micaz and more recently Sentilla), are being adapted for deployment in applications where human wellness maintenance is actively addressed. A number of themes are emerging in this pre-competitive phase of development:

- The quality of the service provided to both the user and to the health care provider is crucial in terms of maximizing BAN market penetration.
- Although some guaranteed level of information flow is a clear necessity for service provision factors such as energy consumption, battery life and size are proving to be just as important factors when it comes to increasing the uptake of new services and systems.
- In community health care settings support for some level of ambulatory motion must be provided without any technical concerns about information loss being a factor.
- Some hardware limitations will inevitably be a feature of the BAN devices that are worn by the user. These limitations should have no impact on the quality of service that is provided. In short BAN devices and systems should be Robust, power aware, mobile, and low cost and be readily implementable in a health care environment. This paper illustrates how these challenges can be addressed using recent developments in the area of systems science. In particular it is shown how Anti-Windup (AW) and Bumpless Transfer (BT) techniques can be applied to the design of next generation BANs that can address the aforementioned issues in an optimal fashion. Although the processing of relevant biometric information can consume valuable energy, it is clear that data transmission is the primary constraint on battery life in a BAN and can account for 70-90% of power usage (Ares et al., 2007). The benefits of transmission power control are obvious when there exists a need for the BAN to remain operational for extended periods of time and to this end a number of wireless network power control algorithms have already been proposed (Walsh et al., 2008; Alavi et al., 2008, Walsh et al., 2009, Alavi et al., 2010, Subramanian et al., 2005, Chen et al., 2006). These schemes have exhibited some success in extending battery lifetime while concurrently providing pre-specified levels of quality of service (QoS). This equates to the provision of sufficient data to reassemble biometric waveforms, (e.g. ECK, EEG, blood oxygen levels, pulse etc.), or to reliably detecting the movement of an elderly person, in an ambient fashion, be they at home or in a care facility.

**A. Remark: Practical Measurement of QoS for Dynamic Control**

In this work QoS will be taken to mean an accurately tracked received signal strength (RSS) target value thereby guaranteeing a bit error rate that is below a certain predefined threshold level. There exists a body of opinion suggesting that RSS is not a suitable metric for this task, largely based on the random variability that has been observed in past mobility experiments. However this work provides practical evidence that the more stable radios that are now a feature of the 802.15.4 market can provide a basis for real time control. In this regard, the results presented here complement the claims made by a number of respected authors in defense of RSS (Ares, 2007). Moreover, no new point of principle arises in the use of any other practicable real time performance metric for BAN purposes, if and when one comes to hand.