Cost Efficient Deployment and Reliable Routing Modeling Based Multi-Objective Optimization for Dynamic Wireless Body Sensor Networks Topology

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ABSTRACT

Wireless Body Sensor Networks (WBSNs), like any other sensor networks, suffer from limited energy and are highly distributed network, where its nodes organize by themselves and each of them has the flexibility of collecting and transmitting patient biomedical information to a sink. When a knowledge was sent to a sink from a path that doesn't have a definite basis, the routing is a crucial challenge in Wireless Body Area Sensor Networks. Furthermore, reliability and routing delay are the considerable factors in these types of networks. More attention should be given to the energy routing issue and frequent topology's change in WBSNs. That increases the dynamics of network topology, and complicates the relay selection process in cooperative communications. Unreliable communication over the wireless channel complicates communication protocols and results in low data yield (Stathopoulos 2005). The deployment sensors step is a crucial and complex task due to several independent objectives and constraints. This paper presents a Min-Max multi-commodity flow model for WBSNs which allows preventing sensor node saturation and taking best action against reliability and the path loss, by imposing an equilibrium use of sensors during the routing process. This model is based on the authors' optimal sensors deployment method for WBSNs. Simulations results show that the algorithm balances the energy consumption of nodes effectively and maximize the network lifetime. It will meet the enhanced WBSNs requirements, including better delivery ratio, less reliable routing overhead.

Keywords: *Deployment, Dynamic topology, Routing, Reliability, Sensors, Wireless Body Sensor Networks (WBAN)*

DOI: 10.4018/ijehmc.2013100102

INTRODUCTION

WBSNs are currently used in multiple ways in the health-care sector. Applications cover patients' telemonitoring health state, tracking and monitoring patients' movements, drug administration and diagnostic applications (Verdone 2008; Penders 2011). In the field of patients health state, WBSNs are particularly useful for patients under medical observation. It allows the integration of intelligent, miniaturized, low-power, invasive/non-invasive sensor nodes in/around a human body that are used to monitor body's functions. Each intelligent node has enough capacity to process and forward informations to the sink for diagnosis and prescription. A WBSNs provides a long term health monitoring for patients under natural physiological states without constraining their normal activities. It is used to develop a smart and an affordable health care system and can be a part of diagnostic procedure, maintenance of a chronic condition, supervised recovery from a surgical procedure, and can handle emergency events.

WBSNs should be robust against frequent changes in the network topology; The data mostly consists of medical information. Hence, high reliability and low delay is required; The devices used in WBSNs have limited energy resources available and consequently the computational power and available memory of such devices will be limited (Ullah 2010; Grosby 2012).

This poses a number of challenges on the design and analysis of WBSNs. Considerable attention had been paid to develop reliable sensor network communication protocols. In summary, new ideas on the fundamental limits for in/on body sensors deployment, routing and reliability in such systems are needed. The new mechanism can maintain the features of WBSNs such as multihop routing and dynamically environmental changes in a complete autonomous mode. Maximizing lifetime and other constraints as reliability are conflicting objectives and thus warrant a trade-off (Jourdan 2004; Santi 2005).

The remainder of this paper is as follows: in the second section, we present works related to our problems. The third section presents our optimal deployment pattern exploration and a mathematical formulation using non-convex optimization. In the fourth section, we introduce in a Min-Max multi-commodity flow description and formulation, based on reliable model and network energy consumption problem. Finally, examples and experimental comparative studies will be discussed in the fifth section, then we will conclude by presenting the future trends of our approach.

RELATED WORK

A lot of research is being done toward energy efficient routing in ad hoc networks and WSNs (Akkaya 2005; Grosby 2012; Ben Elhadj 2012), the proposed solutions are inadequate for WBSNs. Most protocols for WSNs only consider networks with homogeneous sensors and a many-to-one communication paradigm. In many cases the network is considered as a static one. In contrast, a WBSN has heterogeneous sensors devices with stringent realtime requirements due to the sensor-actuator communication. Specialized protocols for WBSNs are therefore needed. In the following, an overview of some existing routing strategies for WBSNs is given. They can be subdivided into two categories: routing based on the temperature of the body and cluster based protocols.

When considering wireless transmission around and on the body, one of some important issues are radiation absorption and heating effects on the human body. To reduce tissue heating the radio's transmission power can be limited or traffic control algorithms can be used. In Ren (2006) rate control is used to reduce the bio-effects in a single-hop network. Another possibility is a protocol that balances the communication over the sensor nodes. An example is the Thermal Aware Routing Algorithm (TARA) that routes data away from high temperature areas (hot spots) (Tang 2005) . The node temperatures are converted into graph weights and minimum temperature routes are obtained. A better energy efficiency and a lower

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