Temperature-Aware Routing Using Secondary Sink in Wireless Body Area Sensor Network

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ABSTRACT

Wireless Body Area Sensor Network (WBASN) is a developing application of Wireless Sensor Network (WSN) which is very useful in diagnosis of human health remotely. Tiny and smart sensors are placed inside or outside of human body which collects useful data time to time from various parts of body and send it to the corresponding medical staff or doctor. In the future, WBASN will surely make a huge change in traditional health monitoring system and will be helpful for elderly people and patients who suffer from difficult physical mobility. WBASN have many challenges while its design and one of main challenge is controlling temperature rise of sensor node during routing when placed inside human body because temperature rise beyond certain limit will be harmful for human body. The study of controlling temperature rise of sensor nodes during data routing comes under the category of Temperature Aware Routing Protocols. In this article the authors have raised a problem called “Energy Hole Problem” under Temperature Aware Routing Protocols which affects the performance of a network.

KEYWORDS

1. INTRODUCTION

In the current competitive and busy life schedule, self-care is normally neglected by people not only due to lack of time but also because of rising cost of health care, which is a serious issue in health monitoring. This can be done via Wireless Body Area Sensor Networks (WBASN), which comes under the umbrella of wireless network and enable remote diagnosis of human health. WBASNs, which is a combination of sensor nodes set, when placed within or on a human body can remotely monitor human health (Cavallari et al., 2014; Chen et al., 2011). Using a WBASN, elderly people and patients who are restricted by physical mobility, no longer require going to hospital on a regular basis. A lot many applications of such types of networks have emerged in recent years ranging from remote patient monitoring to ambient assisted living (Nadeem et al., 2015; Negraa et al., 2016). However, as communication suffers from the harmful effects of radiation and as the node circuitries and the antennas generate heat due to implanted sensors, using WBASN can have adverse effects on

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the human tissue (Hirata and Shiozawa, 2003; Havenith, 2001; Tang et al., 2005; Bag and Bassiouni, 2008). Thus, one of the primary goals while designing a routing mechanism for WBASN is to minimize the heat generated by sensors during communication process. This goal can be achieved by considering temperature as one of the routing metric and such routing protocols are commonly known as temperature aware routing protocols (Oey and Moh, 2013). Extensive research has been done on Temperature Aware Routing over the past decades with very promising results (Oey and Moh, 2013). But, most of them did not consider the problem of “Energy Hole” which severely affects the network lifetime of WBASN. The network lifetime is defined as the period of time between the start of network to the time when the first node of the network expires (Waider and Biswas, 2009). This situation arises due to rapid increase in temperature of neighboring nodes of sink node. As all the data transmission towards the sink node is through its neighboring nodes, these nodes observe a rapid increase in temperature and have a tendency to become hotspot nodes. The situation in which all the neighboring nodes of a sink become hotspot node is called as “Energy Hole Problem”. Moreover, the energy of these nodes also gets depleted quickly. And in this condition no data can be transferred to sink node from any other node even when the average temperature and average energy of the overall network is normal. Neighboring sensor nodes of sink node carry heavier traffic load as compared to other sensor nodes present in the network.

Although this is a well-known problem in wireless sensor networks (WSN) and a lot many solutions have been proposed in past literature for the analysis and avoidance of energy hole problem in WSN (Sharma, 2015) with the most recent work being presented in Ren et al., 2016). The problem of energy hole in Wireless Sensor Networks is mainly due to depletion of energy of sensor nodes surrounding the sink node. This problem has not received due attention in WBASN which also experience energy hole problem not only because of deficiency of energy but also due to rapid increase in temperature of neighboring nodes of sink node or body node coordinator. The category of temperature aware routing protocols is very popular in WBASN. Although they try to avoid hotspot formation and avoidance but most of these protocols overlook the energy hole problem which may lead to serious troubles in case of critical data is to be transmitted to body coordinator. Hence this is a more serious problem in WBASN. The solutions proposed for WSN mainly work on node distribution and transmission power adjustment, and use of multiple sinks or mobile sinks (Sharma, 2015; Ren et al., 2016). The position of sensor nodes in WBASN is fixed before the network is put in use and the position of Body Node Coordinator or sink is also fixed at an optimal location; moreover, the sensors have limited transmit power, hence these solutions are not feasible for WBASN.

In this paper, a new methodology has been proposed to reduce the effect of “Energy Hole Problem” in Temperature Aware Routing Protocols with the aim of increasing the network life time. This is done via selection of an alternate sink whenever all the neighboring nodes of the sink node become hotspot nodes. This alternate sink node plays the role of main sink until some or all of the neighboring nodes of main sink cool down and provide access to the main sink.

Although the concept of multiple and mobile sink is popular in WSN but the solutions are not directly applicable to WBASN. The work in chen et al. (2009) uses multiple sinks to collect huge amount of data from sensor nodes but the objective is to minimize latency. Similarly, the works in Mamatias (2014) and Perillo et al. (2005) use mobile sinks so that the neighborhood of sink node keeps changing resulting in balanced energy consumption throughout the network. The use of mobile sink results in both prolonged network lifetime and minimizing delay in data gathering. The mobile sink may either visit each sensor node and gather data individually or visit few locations in the network and gather data through multi-hop communication (Perillo et al., 2005). These solutions are not feasible for WBSAN where the body node coordinator or sink is placed at an optimal location before data transmission starts and cannot be made mobile during network functioning. Moreover, deploying additional sinks would require additional cost and would not be useful in solving the energy hole problem, although it may help in transferring more data to the sinks. The current work selects
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