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Self-Reconfigurable Biomedical Wireless Sensor Network

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ABSTRACT

An e-health system consists of a group of sensors attached non-invasively to a patient in order to sense the physiological parameters. It has been used in hospitals during the last decades using conventional wired equipment, hence not allowing the patient to move around freely. However, recent advances in wireless sensors technology are changing this scenario by permitting mobile and permanent monitoring of patients, even during their normal daily activities.

The emerging wireless sensor networks (WSN) consist of a group of nodes supplied by low energy batteries, and having very limited sensing, signal processing, and wireless communication capabilities. All nodes transmit data to the same collector node, known as base station (BS). Such networks have been deployed in a wide range of monitoring applications, including e-health and e-emergency.

In an e-health WSN containing one or more body sensor networks (BSN), the physiological signals of a patient are captured by a set of sensors placed on the patient´s body and delivered to a BS. With the help of a diagnosis and decision center, the BS keeps informed about the clinical state progress of each patient in the WSN. According to the clinical state of the patients, the BS may modify how motes in the WSN acquire the signal or access the wireless channel to transmit data. In this last case, the medium access control (MAC) protocol plays an important role regarding throughput, latency and energy efficiency. The MAC protocol should be flexible enough to adapt to new communication situations as required by the BS. For example, if the BS requires a higher sampling rate of the electrocardiography (ECG) signal of a patient, the MAC protocol should be able to guarantee bandwidth enough to that signal (Gama et al., Oct. 2008).

In case of emergency clinical scenarios, a healthcare network should provide quality of service (QoS) facilities since these clearly demand for high reliability, guaranteed bandwidth and short delays (Gama et al., Aug. 2008). Therefore, communication protocol layers need to assure a reliable and timely data delivery. A TDMA-based MAC protocol was conceived in this work for being robust to channel errors, aiming to provide efficient bandwidth allocation, low energy consumption, and bounded latency, as required by e-emergency WSNs. In order to improve its robustness to bit error conditions, the proposed MAC protocol is based on short size beacons, i.e. beacons carrying only the essential information for the proper operation of the WSN, which contains one or more BSNs (Gama et al., Sept. 2009).

Besides the essential information for the proper operation of the WSN, a beacon needs to send reconfiguration instructions if a new BSN is associated to the WSN or a new clinical situation is detected in some BSN. For instance, higher monitoring activity of the vital signs might be required when a patient´s clinical situation becomes critical. Therefore, a new reconfiguration scheme is also proposed in this work so that a WSN may react optimally in accordance with the patients' clinical state (Gama et al., May 2009).

Fundamental in every TDMA-based protocol is the link scheduling, i.e., the time-slot allocation to the network devices. In traditional TDMA-based systems, time-slots are assigned to the devices by the central coordinator of the network. However, some schemes do not require any coordinator, and thereby the time-slot assignment and synchronization become distributed. Sensors in a BSN can be considered as generating constant bit rate traffic where traffic requirements do not change quickly over time. Taking advantage of the stable topology and traffic pattern characteristics found in many e-health WSNs, a simple collaborative time-slot allocation algorithm with QoS requirements is also proposed in this work for one-hop networks. The proposed algorithm can be integrated into any TDMA-based MAC protocols dealing with similar traffic characteristics as found in e-health networks (Gama et al., July 2010).

Simulation results show that the proposed MAC protocol leads to meaningful improvements regarding packet loss ratio and energy consumption when compared with the LPRT MAC protocol (Gama et al., May 2009). Moreover, preliminary results obtained in a real experimental testbed confirm that the strategies adopted by the proposed MAC protocol lead to significant improvements regarding scalability, loss ratio, duplicated packets, and energy consumption, when compared with standard 802.15.4 protocol. Preliminary experimental tests revealed also that the proposed reconfiguration scheme leads to a fast reconfiguration of the WSN.

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ÓSCAR S. GAMA was formed in Electronic Enginneering in the University of Oporto in 1989 and received a Master degree in Informatics from University of Minho (Braga) in 2003. He is currently a PhD student in the Electronics Department of University of Minho. His research focuses in self-reconfiguring e-health wireless sensor networks with quality of service.