Editorial

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1 Introduction

Traditional wireless sensor networks (WSNs) are normally battery powered with limited energy supply (Sendra et al., 2011). Years of effort had been given by researchers and engineers to maximise the lifetime of WSNs in almost all the aspects, e.g., routing (Fersi et al., 2010; Rajeswari and Kalaivaani, 2011), topology control (Matsumae, 2009), MAC protocols (Han et al., 2013), deployment (Xiaoling et al., 2006), data fusion and aggregation (Shu et al., 2011), clustering (Wang et al., 2011) and sleep scheduling (Yuan et al., 2011). However, recently advanced technical developments have allowed sensor nodes to harvest environmental energy from natural sources, e.g., wind, water flow, ocean currents and solar, which enable WSNs to have the rechargeable energy supply (Lloret et al., 2009a). Moreover, it also facilitates the deployment of wearable sensor networks (Garcia et al., 2011; Quwaider and Biswas, 2012). With multiple energy sources, the overall efficiency, reliability and sustainability are enhanced in any WSN application system (Bri et al., 2009; Garcia et al., 2010).

This emerging technical development gives sensor nodes a totally different energy model compared to traditional battery powered sensor nodes, which fundamentally changed the assumption for many existing lifetime optimisation schemes (Segal, 2011). We should look back at almost all traditional challenging issues in WSNs to cope with this new change (Lloret et al., 2009b). New research issues, e.g., power management with multiple energy sources, should also be considered.

This special issue aims at seeking new approaches, methods and schemes for solving both traditional and new challenging issues in WSNs with environmental energy harvesting. Authors are invited to submit complete unpublished papers, which are not under review in any other journal. The topics suggested can be discussed in terms of concepts, state-of-the-art, standards, designs, implementations, running experiments or applications. Topics of interest included the following scopes:

- routing in WSNs with environmental energy harvesting
- sleep scheduling in WSNs with environmental energy harvesting
- topology control in WSNs with environmental energy harvesting
- data aggregation in WSNs with environmental energy harvesting
- clustering in WSNs with environmental energy harvesting
- multimedia streaming in WSNs with environmental energy harvesting
- security in WSNs with environmental energy harvesting
- cross-layer optimisation in WSNs with environmental energy harvesting
- power management in WSNs with environmental energy harvesting
- capacity modelling, performance analysis and theoretical analysis
- mobility management in WSNs with environmental energy harvesting
- transmission in WSNs with environmental energy harvesting.

We have selected the best four papers based on the reviewers' comments. We would like to express our gratitude to the reviewers for their time reviewing the papers and providing useful comments to the authors. The papers have been peer reviewed and have been selected on the basis of their research contribution, quality and relevance to the topic of this special issue.

The remainder of this editorial is structured as follows. Section 2 explains the papers included in the special issue. Finally, Section 3 provides the conclusion and future trends.

2 Accepted papers

In this section we present the accepted papers in our special issue.

The paper 'A group-based wireless body sensors network using energy harvesting for soccer team monitoring' exposes a way to collect physiological data on-the-fly from sportswomen and sportsmen during a match, along with the process of sending these data to a process node by means of low radio coverage device that may use energy harvesting. The nodes are the players themselves, and their mobility becomes a challenging problem that must be solved. The proposal is based on the zone mobility of each player and the dynamic of the game. Every player, despite his or her team is, can be used to route data, so the proposal includes security issues. In the first place, data are collected with wearable sensors that are part of a wireless body area network (WBAN). Every WBAN belongs to a player who becomes a mobile node in a global WSN composed of every single player on field. These mobile nodes have short range radios, with coverage radios under 3 m or 4 m, which allow low power consumption and avoid eavesdropping from stands. Because of low power consumption, an energy harvesting system can be used to provide energy back to the devices. The collected data are encrypted and sent to the mobile network. These data will traverse this network along the path determined by the current topology until one of the multiple sink nodes is located next to the game field. The data will be delivered to the control centre of each team where it will be decrypted only by the corresponding team analyst. The simulations show that the network load is lower when the players have high mobility, but it needs more hops when there is high mobility. In both situations, low mobility and high mobility, the management traffic is low, and in all cases below 250 Kbps.

The paper 'Energy harvesting for wireless sensor networks: applications and challenges in smart grid', presented by Ma et al. provides a comprehensive survey on recent energy harvesting techniques in WSNs. Various energy sources and their harvesting methods are reviewed. This paper also addresses the applications and challenges caused by energy harvesting for WSNs in a smart grid environment, specifically, in the transmission and distribution subsystem and in the smart building subsystem. The study finds that electromagnetic field-based harvesting approaches and corporately utilising available ambient energy are potential solutions to powering the sensors in smart grid.

Tseng et al. authored the paper with title 'An efficient power conservation scheme in non-zero-sum duty-cycle game for wireless sensor networks'. The proposed non-zero-sum duty-cycle game expresses the cooperation between sensor nodes within an overlapping area. The optimal strategy is decided by the formulated equilibrium equation based on Nash Equilibrium. In this paper, the power consumption problem in the overlapping area is defined based on integer linear programming, and a game-based model is proposed and modelled. The cooperative scheme provides the lowest power consumption and the longest network lifetime than other related papers, and achieves the power conservation and traffic relieving.

In 'Energy-aware probing period dimensioning algorithms for mobile WSN-HEAP', Sghaier et al. present two approaches (PPM-BM and PPM-EML) for energy management in mobile sensor networks. Their proposals are focused on improving the discovery procedure (also called probing phase) to maximise the network's lifetime. PPM-BM is based on the residual energy of the node, while PPM-EML is based on the estimation of the geolocalised encounting probabilities learning of nodes of the network. To test the proposals, authors implemented them in three well-known routing protocols of Delay Tolerant Networks: MaxProp, Prophet and Epidemic routing. Experimental results show that both proposals enable the overall WSN to efficiently decrease network energy consumption.

3 Conclusion and future trends

In this special issue we have included the recent advances on energy harvesting in WSNs. We have selected the best four papers based on the reviewers' comments. These papers cover a wide range of topics in the energy harvesting for the WSN research field. They show surveys, real implementations and new methods and strategies.

The future trends in this area are focused on achieving lower costs in the systems deployment, while harvesting higher energy.

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