Int. J. Electron. Commun. (AEÜ) 75 (2017) 108–118

Contents lists available at ScienceDirect

International Journal of Electronics and Communications (AEÜ)

journal homepage: www.elsevier.com/locate/aeue

Regular paper

An energy efficient approach for data collection in wireless sensor networks using public transportation vehicles

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ARTICLE INFO

Article history:
Received 11 October 2016
Accepted 15 March 2017

Keywords:
Mobile sinks
Wireless sensor networks
Nonuniform node distribution
Data collection
Clustering
Energy-aware
Public transportation vehicles

ABSTRACT

Applications of wireless sensor networks (WSNs) involve a large number of energy constrained nodes to monitor the areas of interest, where the energy efficiency is an important concern of network design. Compared to the conventional approach using multihop communication, mobile sinks (MSs) attached to public transportation vehicles, such as buses, are the ideal infrastructure for collecting sensory data. This paper studies the problem of using such MSs to collect data from sensor nodes that are nonuniformly deployed. The proposed protocol aims at balancing the energy consumption, including energy expenditure to transmit data packet and network overhead across the network, to make the network operate as long as possible with all nodes alive. We design an energy-aware unequal clustering algorithm and an energy-aware routing algorithm. Theoretical analysis and simulation results confirm the effectiveness of the proposed approach against the alternative methods.

1. Introduction

A WSN consists of a number of battery-powered sensor nodes. Energy consumption for radio transmissions corresponds to a considerable portion of the total energy consumption at sensor nodes [1]. In traditional WSNs, the sensory data is transmitted from source nodes to a centralized sink via multihop communication. A side effect of this approach is that the nodes closer to the sink are more overloaded than others. This issue is known as the funneling effect [2], since the neighbour nodes of the sink represent the bottleneck of network lifetime.

Recent studies have shown that using MSs to collect data in WSNs can relieve the funneling effect issue [3,4]. A MS traversing the sensing field can collect data from sensor nodes over a short range communication link [5,6], and then the on-board MS transmits the collected data wirelessly to a remote center, since it has no energy limitation. Long-hop relaying is not used at sensor nodes and the energy consumption is reduced. Traversing the sensing field by MS needs to be timely and efficient because failure to visit some parts of the field leads to data loss, and infrequently visiting some areas results in long delivery delay. Besides, the trajectory planning of MS in these cases become more difficult to cope with. Furthermore, in the urban areas, the planned trajectory sometimes cannot be realized since the MS is constrained to roads. Alternatively, amounting MS on a vehicle, such as a bus, avoids some difficulties and can provide better performance for data collection. First, since the bus is already a component of the environment and its trajectory is predefined, the difficult path planning and complex control of MS's movement are avoided. Second, instead of visiting each sensor node individually, which is a time consuming task due to the low physical speed of MS, combining multihop communication with path constrained MS is able to increase the data delivery delay.

This paper investigates using a MS, which is attached to a bus, to collect data in WSNs with nonuniform node distribution. Such WSNs exist in many applications. For example, in the case of monitoring the air pollution of a city, the industrial areas are usually deployed with more sensors than the residential areas. Also, since the areas of interest may be isolated from each other, using conventional data collection approaches is not appropriate due to the limited budget of energy resource. In this case, exploiting a MS amounted on a bus is able to relieve the bottleneck of energy at sensor nodes. Because the MS can serve the isolated areas at different time. It is like that there is a virtual static sink for each area and such sink only works at specified time duration. The specified time duration is the duration during which the MS is in the area. Instead of the coverage problem studied in our previous work [7–9], the focus here is on routing the sensory data from source

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http://dx.doi.org/10.1016/j.aeue.2017.03.012
1434-8411/