Journal of Network and Computer Applications 34 (2011) 1997–2010

Contents lists available at ScienceDirect

Journal of Network and Computer Applications

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

A family of simple distributed minimum connected dominating set-based topology construction algorithms

Pedro M. Wightman [a,*], Miguel A. Labrador [b,**]

[a] Departamento de Ingeniería de Sistemas, Universidad del Norte, Km. 5 Vía a Puerto Colombia, Barranquilla, Colombia
[b] Department of Computer Science and Engineering, University of South Florida, 4202 E. Fowler Ave., Tampa, FL 33620, USA

A R T I C L E I N F O

Article history:
Received 27 October 2010
Received in revised form
15 March 2011
Accepted 18 July 2011
Available online 29 July 2011

Keywords:
Topology control
A3
Distributed protocols
Atarraya
Wireless sensor networks
Connectivity
Coverage

A B S T R A C T

This paper considers the problem of topology construction to save energy in wireless sensor networks. The proposed topology construction mechanisms build reduced topologies using the Connected Dominating Set approach in a distributed, efficient, and simple manner. This problem is very challenging because the solution must provide a connected network with complete coverage of the area of interest using the minimum number of nodes possible. Further, the algorithms need to be computationally inexpensive and the protocols simple enough in terms of their message and computation complexity, so they do not consume more energy creating the reduced topology than the energy that they are supposed to save. In addition, it is desirable to reduce or completely eliminate the need of localization mechanisms since they introduce additional costs and energy consumption. To this end, we present the family of *A3* distributed topology construction algorithms, four simple algorithms that build reduced topologies with very low computational and message complexity without the need of localization information: *A3*, *A3Cov*, *A3Lite* and *A3CovLite*. The algorithms are compared in sparse and dense networks versus optimal theoretical bounds for connected-coverage topologies and two distributed heuristics found in the literature using the number of active nodes and the ratio of coverage as the main performance metrics. The results demonstrate that there is no clear winner, and rather, trade offs exist. If coverage is not as critical as energy (network lifetime), it would be better to use *A3Lite*, as it needs fewer number of nodes and messages. If coverage is very important for the application, then the *A3CovLite* is the best option mostly because of the lower message complexity.

1. Introduction

A wireless sensor networks (WSNs) typically consists of small wireless devices deployed over the physical environment, which cooperate in sensing, processing, and communication tasks to provide data about the variables of interest for monitoring and decision making purposes. There are many application scenarios in which this lightweight, ad hoc, self-configured, and relatively cheap communication infrastructure can be used.

The applicability of WSNs has been limited by its own physical constraints, particularly in those cases where large deployments and more complex applications are required. It is well-known that WSNs have very limited computation, communication, and storage capabilities, and energy resources, and the design of simple, scalable, and energy-efficient algorithms and communication protocols is very challenging and important.

Topology Control is a well-known strategy to save energy and extend the lifetime of wireless sensor networks. Topology control consists of two processes, *Topology Construction* and *Topology Maintenance*. While topology construction builds a reduced topology, topology maintenance recreates, restores, or rotates the topology to preserve connectivity and coverage once the reduced topology is no longer adequate. This paper is about *Topology Construction*, a well-known strategy to save energy and extend the lifetime of wireless sensor networks. Topology construction encompasses those algorithms and protocols that, given a set of nodes, build a reduced topology while preserving important network characteristics, such as connectivity and coverage. The reduced topology, which consumes less energy than the original, is simplified by either reducing the transmission power of the nodes or turning unnecessary (redundant) nodes off.

The problem of topology construction is not simple. First of all, the algorithms and protocols must run in a distributed manner, so they can be implemented in large networks. Second, topology

* Corresponding author.
** Principal corresponding author.
E-mail addresses: pwightman@uninorte.edu.co (P.M. Wightman), labrador@cse.usf.edu, mlabrador@usf.edu (M.A. Labrador).

1084-8045/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jnca.2011.07.007