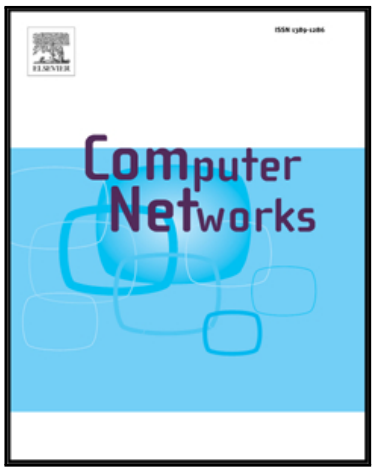

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A Novel Distributed Algorithm for Constructing Virtual Backbones in Wireless Sensor Networks☆

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Abstract

In Wireless Sensor Networks (WSNs), energy saving techniques are critical for efficient routing. The Connected Dominating Set (CDS) used as a virtual backbone for saving energy in WSN has been extensively studied in the past two decades. Since the time complexity and performance ratio are two important metrics to evaluate algorithms, reducing the time expenditure of algorithm and the total number of sensors in CDS are two key problems for CDS construction. In this paper, we propose a novel distributed algorithm, Dominating Set based on Link and Degree and Connecting Tree (LDDS-CT), to find a Minimum CDS (MCDS). LDDS-CT is divided into two phases. In the first phase, a Dominating Set (DS) is constructed using LDDS. In the second phase, a CT algorithm for connecting all sensors in DS is proposed, which can guarantee the number of connectors added to DS is minimized. This paper proves that the time cost of LDDS-CT is at most $2.25n$ and the performance ratio of LDDS-CT is at most $14.798opt + 9.748$, where n is the number of sensors and opt is the size of any MCDS. To the best of our knowledge, LDDS-CT is the fastest two-phased distributed algorithm for MCDS construction with unknown network topology. And the performance ratio of the proposed algorithm is close to the sate-of-the-art algorithms in theory. The simulation results show that LDDS-CT outperforms the existing distributed algorithms.

Keywords: Wireless Sensor Network, Distributed Algorithm, Connected Dominating Set, Unit Disk Graph, Virtual Backbone, Energy Efficiency

1. Introduction

Wireless Sensor Networks (WSNs) do not have any infrastructure and consist of sensors that are able to sense their environment and perform communicating tasks. WSNs have many applications, such as home automation, traffic control, health care applications, environmental monitoring, battlefield detection and agriculture [1].

In WSNs, each sensor participates in routing or broadcasting by forwarding messages to others. Sensors are expected to work on batteries for several months without replenishing. However, the sensors in WSN are small electronic devices with limited energy supply, which restricts the network lifetime. Therefore, energy efficiency is crucial for prolonging the lifetime of the WSN. A special connected component of the network, called a Connected Dominating Set (CDS), is widely used as a virtual backbone for efficient routing and energy saving in such a network.

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