Chapter 3
Connected Dominating Set in Wireless Sensor Network

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ABSTRACT

In a Wireless Sensor Network (WSN), all the nodes are deployed randomly and are energy constrained. There is no physical backbone infrastructure. So, for effective communication between the nodes, a virtual backbone can be used. A virtual backbone can be formed by constructing the Connected Dominating Set (CDS). In past few years, efficient and fast construction of CDS in a wireless network is the main research problem in topology control. In this chapter, the authors have given a comprehensive survey of the CDS construction algorithms with their merit and demerits. They concluded the chapter with some open problems and interesting issues in this field are proposed.

INTRODUCTION

Wireless sensor networks (WSN) are popularly used in the health-care industry, food industry, agriculture and also in a wide range of military applications, such as search and rescue, disaster control (Salhieh et al., 2001) etc. They form a pivotal role in the next generation network in providing flexible deployment and mobile connectivity. Unlike wired networks or cellular networks, there is no physical backbone infrastructure installed in wireless sensor networks. The wireless sensor networks can be static or dynamic. A static wireless sensor network consists of only static nodes, whereas in a dynamic sensor network some of the nodes may be mobile in nature. In both type of networks, each node having an omni-directional antenna, can broadcast messages to all the nodes within its transmission range. Therefore, through broadcasting, a node can reach all of its nearby nodes with one emission. If two nodes are outside the single hop radio transmission range of each other, then a communicating session is established through multi-hop links by some intermediate nodes for relaying messages (multi-hop routing). A simple method for multi-hop routing between non-adjacent nodes in wireless networks is pure flooding, where a node

DOI: 10.4018/978-1-5225-0486-3.ch003

retransmits a packet only once after having received it. However, owing to the low available bandwidth of the wireless channels and the redundant retransmissions generated through pure flooding, the latter is not an efficient communication mechanism in wireless networks. These challenges of low bandwidth, the memory and battery life limitations of sensor nodes, open up new paradigms for multi-hop routing in wireless sensor networks. One of the most popular means of overcoming these challenges in multi-hop routing in WSNs is through the use of a virtual backbone.

A virtual backbone is the set nodes which takes some additional responsibilities to help in routing. Any non-backbone node can send a message to another destination node by forwarding a message directly to a neighboring backbone node. By using virtual backbone the routing path search space can be reduced to the set of backbone nodes only. A wireless sensor network can be modeled by a graph. The connected dominating set (CDS) of a graph can be used as the virtual backbone for the corresponding WSN.

A dominating set (DS) of a network is a subset of nodes such that any node not in the subset is a neighbor of some element of that subset. It forms a CDS, if the graph induced by this set is connected. The CDS can receive a packet from any node in the network and retransmit it to any other remote node. A node which is not in the CDS can send a message to any other node through the CDS nodes. First it sends its message to one of its neighboring CDS nodes. Now, the search space for any route is reduced to the CDS. If the destination is within the CDS it can get the message directly, otherwise it gets the message from one of its neighboring CDS nodes. Thus, during routing, broadcasting responsibilities lies only with the CDS nodes, instead of all the nodes in the network. Each CDS node keeps track of its neighboring non-CDS nodes. Also the nodes in the CDS can work as virtual backbone for providing a path to a base station. One approach for power conservation can be every node outside the virtual backbone shuts off its radio when it does not have any data to send. So restricting the routing activity to the CDS nodes gives a significant reduction in message overhead associated with routing updates. As only the CDS nodes maintain routing information, we can save the storage space by reducing the CDS size. So, it is desirable to construct a minimum connected dominating set of (MCDS) of the network which can make the routing easier and reduce the communication overhead. In this chapter, first we describe various network models and then in the following sections discuss various CDS construction techniques and examine their characteristics. Finally, we conclude the chapter with some important issues and also proposed some open problems.

NETWORK MODEL AND RELATED DEFINITIONS

To develop the various CDS construction algorithms and to find their performances, various network models have been proposed in the literature by various authors. In this section, firstly we discuss various network models and then we discuss the definitions used throughout this chapter.

Network Models

A wireless network can be represented by a graph $G = (V, E)$, where V represents the set of nodes present in the network and E represents the set of all links between them. Using a graph to represent a wireless network we have the following types of models: