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Learning Automaton based Topology Control Protocol for Extending Wireless Sensor Networks Lifetime

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Abstract

Energy efficiency is one of the critical challenges in wireless sensor networks because the nodes in such networks have limited resources. Therefore, they should be managed efficiently in order to exploit the network's functionality for a longer period of time. Topology control mechanisms can help the nodes to leverage their resources efficiently. Several topology control protocols for WSNs have been proposed to decrease energy consumption of the nodes and increase the network capacity. Leveraging a lower transmission range can help the nodes to mitigate their energy consumptions. In this paper, we propose a topology control protocol based on learning automaton, which is named LBLATC. The learning automaton of every sensor node chooses the proper transmission range of the node using the reinforcement signal which is produced by the learning automaton of neighbor sensor nodes. The simulation runs carried out to verify the performance of the proposed protocol. It acts on average 15% better than current state-of-art in term of selecting a proper transmission range.

Keywords: Topology Control, Learning Automaton (LA), Sensor Transmission, Energy Efficiency

1. Introduction

Wireless sensor networks (WSNs) have been widely used in many fields like surveillance systems, detecting unexpected events, environmental monitoring, military, etc. [1]. The proliferation of these network creates Internet of Things (IoT) [2]. As such, WSNs are widely used in IoT applications to gather the information around us. Sensor nodes in WSNs have many resource limitations such as battery, computation, etc. Therefore, it is necessary to save their resources in order to use the network for a long period of time. Thus, energy efficiency is a key issue in these networks [3, 4]. Coverage and topology control algorithms have impact on the lifetime of WSNs. Therefore, coverage and topology control algorithms have been considered in many research works. For example, a learning automaton based method to meet the coverage requirements of a network is proposed in [5] to improve overall lifetime of the network.

In this paper, we consider the problem of extending wireless sensor networks (WSNs) lifetime. As data transmission constitutes the highest energy consumption tasks in WSNs, an efficient mechanism for data transmission in WSNs is a common approach for optimizing the energy usage of sensor nodes. Therefore, one of the main objectives of topology control mechanisms in WSNs is to coordinate the network's nodes by choosing a suitable transmission range for them. This helps in creating a network with few links between the nodes. Therefore, the energy consumptions are minimized and the network lifetime can be increased. As suitable topology can boost the performance of a network, several protocols have been proposed to adjust the transmission ranges of nodes in sensor networks [6, 7, 8]. The quality of the selection differs according to different priorities and conditions. Each selection criteria can have different performance because it has a direct effect on energy consumption of the nodes. One of the advantages of adjusting the transmission range is that the obtained topology is not too dense. Therefore, exploiting less dense work results in having less intermission among the selected nodes which is not considered by recent state-of-art works in [9, 10, 11].

In homogeneous networks, all nodes have the same transmission range. However, these networks do not have a proper efficiency, durability, and robustness. Heterogeneous networks, also, use sensors with the same transmission ranges, and, despite the density in neighboring sensors, each sensor chooses its own transmission range to maintain the network connectivity. As a result, such networks are more robust and efficient than homogeneous ones [9, 10].

In this paper, we propose a novel topology control protocol based on learning automaton. The proposed algorithm

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