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A NOVEL DISTRIBUTED CLUSTERING PROTOCOL USING FUZZY LOGIC

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Abstract

Energy resource constraint is an important issue in wireless sensor networks. An efficient solution to this issue is clustering approach; which markes the network nodes as cluster heads (CHs) and cluster members (CMs). In the clustering method cluster members send packets to the cluster head and CHs forward the received packets to the sink. CH selection mechanism has direct effect on the energy efficiency and network coverage of WSN. In this paper a new distributed clustering approach using fuzzy logic is proposed. Our proposed method uses Fuzzy logic to assign CH selection chance to network nodes in order to choose tentative and final CHs. simulation results demonstrate that our approach reachs to better network lifetime, energy efficiency and network coverage in comparison with UCFIA, GCA, and SCP.

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Keywords: Wireless sensor networks; Clustering; Fuzzy Logic; Network Lifetime.

1. INTRODUCTION

Wireless sensor networks are composed of thousands inexpensive and intelligent sensor nodes which are deployed randomly over a region. In these networks, main constraints of sensor nodes are energy resource, processing power, communication bandwidth and etc. [1]. The power supply of sensor nodes in WSNs is small batteries, that usually could not be recharged or replaced. So the most important issue in WSN is network lifetime, and the best solution is energy efficient protocols. Recently, the clustering is introduced as an energy-saving method, and the good performance of WSN is strongly dependent on the energy-efficient clustering mechanism [2]. Using the clustering method in the sensor networks leads to the following advantage:

- Low energy consumption
- long lifetime
- Facilitate collaborative signal processing

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- Facilitate data aggregation
- Reduce communication bandwidth
- Increase scalability and robustness of network

In order to have more efficient clustering mechanism three main issues should be considered: 1) low energy consumption during clustering, 2) good distribution of cluster heads to reach high coverage and 3) low number of orphan nodes. LEACH [3] (Low Energy Adaptive Clustering Hierarchy) is one of the classic clustering protocols which only consider the probability for each node to become cluster head. But the location and the residual energy of nodes, does not take into account and leads to the early death of some nodes and the overall invalidity of the network. In GCA [4], a gradual cluster head election algorithm is proposed that gradually elects cluster heads according to the proximity to neighbour nodes and the residual energy level at each clustering step. This method guarantees the networks connectivity and coverage by increasing the number of CHs. But the critical issue which must be considered is increasing collision probability by increasing the number of CHs. In the DAC [5], a new duplication avoidance method is proposed. Each node has a random number generator based on the logistic map function and with random updating in each round, it can decide to be either a cluster head or not without any control overheads. This method has lower coverage than GCA. In TCAC [6], the authors present a new topology control mechanism in which the nodes can control their transmission power level. This technique ensures that any elected cluster head is connected under an optimal degree which is determined by the number of neighbours for uniform distribution of nodes throughout the time. In SCP [7], a staggered clustering protocol is proposed which selects the high energy node with low communication cost as a cluster-head, and also considers the load balancing. Authors in [8] introduced the fuzzy logic on demand clustering, in which node's remaining energy is considered for non-probabilistic CH election. In [8], communication between CHs and BS is done in a multi-hop fashion. In [9], a new unequal clustering scheme based on fuzzy logic (UCFIA) is proposed where local information of tentative cluster heads including residual energy, distance to base station and local density are considered. Then the tentative cluster heads' chance and their competence radius are found. Also adaptive max-min ant colony optimization is used to construct the energy-aware inter-cluster routing between cluster heads and base station (BS). Fuzzy Logic [10,11] is used in clustering for Merging different clustering parameters according to predefined rules and then electing CHs based on the result. Besides, as mentioned in [8] the overhead of cluster head election may be highly reduced by using fuzzy logic.

This paper proposes a new distributed clustering approach using fuzzy logic to address all the goals mentioned above. First, the fuzzy logic is employed to assess the chance of a node to become a CH. Node density, node energy and node's centrality are taken into account to calculate the cluster head's chance. We suppose that CHs send their information to the BS in single-hop fashion. The proposed method is compared with UCFIA, GCA and SCP protocols. As mentioned before, GCA has a high coverage but large number of CHs increases collision probability. In SCP nodes with high residual energy are selected as CHs, but lower coverage in comparison with UCFIA is considered as negative point of this method. The obtained results show that the proposed method has better coverage and provides superior network lifetime and energy savings. Also by using fuzzy logic, nodes with the best situation are selected as cluster head. The rest of the paper is organized as follows: In section 2, our new clustering method is presented. Simulation results are discussed in section 3, and finally, the paper is concluded in section 4.

2. PROPOSED METHOD

Three following assumptions are used in proposed clustering mechanism:

- All nodes have the same initial energy and the BS knows this value.
- The BS knows the size of considered environment.
- The BS has information about the initial number of nodes in the network

At the beginning of the proposed network deployment, the BS broadcasts a beacon signal to all sensor nodes which contains some necessary information such as the initial energy of the sensor nodes in the network, number of nodes in the network and network dimension. The same process is used by the sensor nodes, to determine the number of their