

Chapter 44

F3N: An Intelligent Fuzzy-Based Cluster Head Selection System for WSNs and Its Performance Evaluation

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ABSTRACT

Sensor networks supported by recent technological advances in low power wireless communications along with silicon integration of various functionalities are emerging as a critically important computer class that enable novel and low cost applications. There are many fundamental problems that Wireless Sensor Networks (WSNs) research will have to address in order to ensure a reasonable degree of cost and system quality. Cluster formation and cluster head selection are important problems in WSN applications and can drastically affect the network's communication energy dissipation. However, selecting of the cluster head is not easy in different environments which may have different characteristics. In this paper, in order to deal with this problem, the authors propose a power reduction algorithm for WSNs based on Fuzzy Logic (FL) and Number of Neighbour Nodes (3N). They call this system F3N. The authors evaluate F3N and LEACH by many simulation results. The performance of F3N system is evaluated for three different parameters: Remaining Battery Power of Sensor (RPS); Degree of Number of Neighbour Nodes (D3N); and Distance from Cluster Centroid (DCC). From the simulation results, they found that the probability of a sensor node to be a cluster head is increased with increase of number of neighbour nodes and remained battery power and is decreased with the increase of distance from the cluster centroid.

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INTRODUCTION

The developments in technologies such as wireless communication and microelectronics have enabled Wireless Sensor Network (WSN) applications to be deployed for many applications such as battlefield surveillance and environment monitoring. An important aspect of such networks is that the nodes are unattended, resource-constrained, their energy cannot be replenished and network topology is unknown. The resource constrained limitations make it essential for these sensor nodes to conserve energy to increase life-time of the sensor network (Akyildiz, Su, Sankarasubramaniam & Cayirici, 2002; Akyildiz & Kasimoglu, 2004; Giordano & Rosenberg, 2006; Karaki & Kamal, 2004; Yang, Mino, Barolli, Ikeda, Xhafa & Duresi, 2011; Wang, Huang & Lin, 2012).

Recently, there are lot of research efforts towards the optimization of standard communication paradigms for such networks. In fact, the traditional Wireless Network (WN) design has never paid attention to constraints such as the limited or scarce energy of nodes and their computational power. Also, in WSN paths can change over time, because of time-varying characteristics of links, local contention level and nodes reliability. These problems are important especially in a multi-hop scenario, where nodes accomplish also at the routing of other nodes' packets (Al-Karaki & Kamal, 2004).

There are many fundamental problems that sensor networks research will have to address in order to ensure a reasonable degree of cost and system quality. Some of these problems include sensor node clustering, Cluster Head (CH) selection and energy dissipation. There are many research works that deal with these challenges (Chatterjee, Das & Turgut, 2002; Banerjee & Khuller, 2001; Chen, How & Sha, 2004; Basagni, 1999; Amis, Prakash, Vuong & Huynh, 2000; Chan & Perrig, 2004; Heinzelman, Chandrakasan & Balakrishnan, 2004; Heinzelman, Chandrakasan & Balakrishnan, 2000; Lindsey, Raghvendra & Sivalingam, 2002).

The cluster based algorithms could be used for partitioning the sensor nodes into subgroups for task subdivision or energy management. Cluster formation is one of most important problems in sensor network applications and can drastically affect the network's communication energy dissipation. Clustering is performed by assigning each sensor node to a specific CH. All communication to (from) each sensor node is carried out through its corresponding CH node. Obviously one would like to have each sensor to communicate with the closest CH node to conserve its energy, however CH nodes can usually handle a specific number of communication channels. Therefore, there is a maximum number of sensors that each CH node can handle. This does not allow each sensor to communicate to its closest CH node, because the CH node might have already reached its service capacity. CHs can fuse data from sensors to minimize the amount of data to be sent to the sink. When network size increases, clusters can also be organized hierarchically.

In the conventional cluster architecture, clusters are formed statically at the time of network deployment. The attributes of each cluster, such as the size of a cluster, the area it covers, and the members it possesses, are static. In spite of its simplicity, the static cluster architecture suffers from several drawbacks. The fixed membership is not robust from the perspective of fault tolerance. If a CH dies of power depletion, all the sensors in the cluster render useless. Also, fixed membership prevents sensor nodes in different clusters from sharing information and collaborating on data processing. Dynamic cluster architectures, on the other hand, offer several desirable features. Formation of a cluster is triggered by certain events of interest.

When a sensor with sufficient battery and computational power detects (with a high Signal-to-Noise Ratio: SNR) signals of interest, it volunteers to act as a CH. This is a simple method, because no explicit leader (CH) election is required and, hence, no excessive message exchanges are

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