Dual Transmission Power and Ant Colony Optimization based Lifespan Maximization Protocol for Sensor Networks

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ABSTRACT

A main characteristic of wireless sensor network (WSN) is its limited battery power. Non-uniform energy depletion in WSN, leads to formation of energy holes in certain areas of network. For a uniform consumption of energy among sensor nodes, some points should be considered like the residual energy of the nodes, energy consumed in the communication and route length. In this work, the authors has achieved the uniform consumption of energy by using dissimilar transmission power levels for communication between cluster heads and the sink node, and for intra-cluster communication. Further, they have used ant colony optimization technique for routing between the base station and sensors which are not the member of any cluster. They have proposed dual transmission power levels and ant colony optimization based (DTP-ACO) protocol to improve the lifespan of the network. Results demonstrate that DTP-ACO protocol outperforms LEACH protocol in provisions of the life span, residual energy, packets sent to the base station and throughput of the network.

Keywords: Ant Colony Optimization, Clustering, Dual Power Levels, Network Lifespan, Uniform Energy Consumption

1. INTRODUCTION

Deploying sensor nodes into an advanced communication setup is called wireless sensor network or sensor networks (Akyildiz, 2002). Small sized and low priced sensors are being used in a variety of application (Puccinelli, 2005; Haenggi, 2004). Sensor network interacts with the outer world through the sink node or the base station (BS). Sensors are deployed to sense some event in the environment. When an event happens, it causes sensors to sense and transmit the event information towards the sink. A key constraint in sensor networks is the energy depletion of sensor’s battery power. The stream of information in a network trails a many-to one arrangement, where sensors closer to the base station convey substantial traffic burdens. Consequently, the sensors

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nearby the base station would exhaust their energy sooner, hence energy holes (Watfa, 2013; Sharma, 2015a; Sharma, 2015b) emerges around the base station. The purpose of this research work is to astound the power limitations in WSN by reducing transmission energy consumption in intra-cluster communication and to improve the lifespan of the network by using ant colony optimization (ACO). There are various types of routing protocols used in WSNs like hierarchical, flat, multipath, single path and ad-hoc routing protocols (Sun, 2005; Sharma, 2015c). Network performance can be significantly improved by clustering technique. LEACH (Heinzelman, 2000) is a popular clustering based hierarchical routing protocol. LEACH divides the sensor network into cluster heads and member nodes. Cluster heads (CHs) are selected sensors which can receive, aggregate and transmit data towards the sink node during a round. However, intra-cluster communication does not require the same energy as communication between CHs and the sink node. Nodes which are very close to a CH does not deplete the same amount of energy as nodes, which are far off from the CH. So a different transmission power level is required for cluster members and cluster heads. After a cluster setup, it is possible that the clusters are not uniformly distributed in the monitored area, some nodes in the network are not members of any cluster head as we have only p% cluster heads available in the network at round (Heinzelman, 2000). Therefore, the remaining nodes in the network will choose a multipath routing algorithm to transmit data to the base station. To improve the lifespan of the sensor network, route length and energy depletion in communication for a multipath routing algorithm must be considered. Route length and energy depletion pattern of nodes are networked parameters. Optimization of these parameters might be considered as a combinatorial optimization issue. We have used an ACO algorithm (Dorigo, 1996) to facilitate transmission between uncovering nodes and the sink. Nodes which are not covered by CHs transmit their data to the sink by using ACO algorithm. ACO is a heuristic approach for resolving combinatorial optimization issues (Dorigo, 2004). DTP-ACO is a hierarchical routing protocol, which allows sensors within a cluster to transmit data to cluster head with lower transmission power as equated to other sensors in the sensor network. We have set an optimum radius around the cluster head, nodes within the optimum radius transmit with a low power level. Nodes outside of this radius forms an optimized routing path to the base station by using ant colony optimization algorithm and transmit with high energy level. Cluster heads nodes also transmit with high power level. The remainder of the paper is planned as follows. Section 2 describes the related work which describes several types of clustering and ACO based routing protocols. Section 3 explains the proposed protocol, Section 4 explains the proposed methods by using a flowchart. Section 5 provides the details of simulation setup and results. Section 6 concludes the proposed method and simulation results. Section 7 discusses the future work and scope of the protocol.

2. RELATED WORK

LEACH (Heinzelman, 2000) is an application precise clustering based protocol. It assumes that all the sensors are able of connecting with any other sensor in the monitored area. However, this affects network scalability as LEACH does not assure a fair distribution of CHs among sensors. Authors in (Lindsey, 2002) have presented chain based clustering method PEGASIS to increase the performance of the LEACH protocol. Sharma et al. have proposed an inter-cluster communication protocol and ensured a fair distribution of CHs in the WSN (Sharma, 2015d). CHs are selected based on the remaining power of the nodes in the region. If the energy of a region is below a threshold value, CHs are chosen from another region. Clustering based routing protocols are suitable for sensor networks as these protocols are power efficient and provide data
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