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AOMDV with Multi-Tier Multi-Hop Clustering in Wireless Sensor Networks

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Abstract: In recent years numerous specialists exhibited their remarkable energy models to cluster based energy efficient routing in Wireless sensor networks (WSNs). In wireless sensor networks, nodes execute on confined force batteries that brings about reducing its lifetime, henceforth WSNs are viewed as a force devouring plans. As the wireless sensor nodes are greatly energy based, the energy efficient routing protocols are necessary with the aim of balancing and reducing energy consumption over the whole network. Subsequently, several specialists have proposed distinct routing protocols for sensor networks, especially routing protocols depending on clustering scheme to minimize the energy utilization in wireless sensor network. This is on the account of the utilization of cluster based routing that has various benefits like to minimize control messages, re-usability of bandwidth and diminishing the energy consumption by aggregating data at intermediate sensors. This article presents a multi-tier multi-hop clustering scheme to reduce the energy consumption of wireless sensor network in which, multipath-AODV routing protocol is used to route the data from source to destination. In the demonstration of simulation results, as compare to LEACH the proposed algorithm provides higher performance and longer network lifetime.

Keywords: Wireless sensor network, Clustering scheme, Data aggregating, Energy efficiency, Network lifetime, LEACH

1 Introduction

The continuous advancements in wireless communication technologies have prompted the advancement of minimal effort, low power and multifunctional miniature sensor nodes[1]. In WSNs sensor nodes could be conveyed to gather convenient data from the field. After the successful deployment, the sensor nodes develop a communication network, for the coordination purpose, called Wireless sensor network (WSN) [2]. The application area of wireless sensor networks is very vast as it meets the objectives of security, localization, surveillance, temperature, pressure, motion, pollutants, military defense, anti-terrorism, relief, environment tracking and many other fields[3] [4][5]. A Wireless Sensor Network has some limiting factors as limited power battery and constrained energy consumption in WSN, so energy consumption is one of the most important issues in WSN. The main source of power consumption is communication [6]. As expressed by the network topology, we recognize three classes of routing techniques: flat, tree and hierarchical routing techniques. As the name itself signifies, in flat routing, all sensor nodes have the same level of privilege. They all hold the responsibility of sensing and communication. The flat routing is suitable for small scale WSN as the cost of constructing and maintaining routing is very high [7]. In tree routing, there is a tree that yokes all nodes in the network. The child node relays data to father node. In order, the data is delayed to root along the tree. The benefit of the tree routing is that it is easy to construct a tree connecting all nodes. But the scalability of it is not good. Because it needs to construct the routing tree again when a node switches or be inoperative. So it is fit of the small-scale WSN. Unlike former classes, in hierarchical WSNs, the network organization is in the form of clusters. Each cluster contains one special node called cluster head (CH), and its member nodes called non-CHs. The CH forwards the data sent by its members to the BS. The hierarchical or cluster routing, are well-known techniques with special advantages related scalability and efficient communication. Thus, it is usually utilized to perform energy-efficient routing in a WSN.

The rest of the article is organized as follows. Section 2 presents the related work regarding the routing

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techniques, Section 3 describes the proposed LEACH algorithm, Section 4 describes AOMDV Protocol, Section 5 gives the performance evaluation of proposed algorithm and Section 6 gives the conclusions.

2 RELATED WORK AND MOTIVATION

2.1 Related Work

The main target of routing algorithms is to efficiently lessen the energy consumption of nodes when it needs to communicate the data to the destination. Presently, the routing problem has been receiving huge attention. There are all kinds of routing algorithms being developed in the WSN.

In [8], the authors proposed two new algorithms under name PEDAP (Power data gathering and aggregation protocol PEDPA), which are tree based routing schemes. The proposed algorithms are effective in enhancing the network lifetime of WSN. However, PEDAP wants that each node can obtain energy information of its neighbours and needs involve sink in forming a spanning tree. So the scalability of this algorithm is not good.

Direct Diffusion (DD) [9], is typically follow data centric and flat routing principles. A node pleads for data by forwarding interests for naming data. A sensing work is propagated within the whole network. The nodes which show interest, arranged their own gradients throughout the network to which the data transmission is carried out. During the delivery of data, reinforcement and negative reinforcement techniques are used for systematic distribution. The main flaw of DD is that the flooding algorithm is used in DD, which reduces the energy efficiency of DD.

In [10], the authors present a new algorithm under name PEGASIS (Power Efficient Gathering in Sensor Information System), which is a chain based power efficient protocol. The construction of chain is done according to a greedy algorithm, where each node selects their closest neighbor as the next hop in the chain. Communication within the chain is carried out sequentially. Each node within the chain collects data from its neighbor until all the data are gathered at one sensor node called chain leader. Chain leader manages the communication order by passing the token among the nodes. The main shortcoming of PEGASIS is that it assumes all the nodes have global knowledge about the network.

There are some other algorithms presented in [11][12][13], that provided other algorithms to save energy. Although the above typical adaptive algorithms achieve better energy efficiency of WSN, more work is still needed to find more efficient, scalable and robust routing scheme to lessen energy consumption and prolonging network's lifetime in small and large WSNs.

2.2 Motivation

One of the conventional and most mainstream clustering protocols proposed for WSNs was LEACH (Low Energy Adaptive Clustering Hierarchy) [14]. LEACH is presumably the first dynamic clustering protocol to address specifically the WSNs needs, using homogeneous stationary sensor nodes arbitrarily conveyed, and in any case it serves as the groundwork for other enhanced clustering protocols for WSNs. It inaugurates the concept of rounds. The behaviour of LEACH is usually separated into two phases, the set-up and the steady state. In the setup phase, the sensor nodes participate in becoming a cluster-head (CH) according to formula equation 1 and 2.

$$T_{(n)} = P/1 - p(rmod1/p), n\varepsilon G \quad (1)$$

$$T_{(n)} = 0, otherwise \quad (2)$$

Where r is the ongoing round, p is the pre decided percentage of CHs; G is the set of sensor nodes that have not been CHs in the last 1/p. In steady state phase, the non-CHs begin sensing and communicating data to its CH. Then data aggregation is executed in CHs. A Time Division Multiple Access technique is used for communication in each cluster. However, this routing technique has also some limitations as explained below

1. The election of cluster heads doesn't use energy. Hence, low power nodes can become CHs and these low power sensor nodes die quickly and produce a disconnection between the sink and WSN.
2. LEACH is not applicable to those WSNs that are deployed in large regions because it uses single hop routing where each sensor node can communicate directly to the cluster head and the base station.
3. At every round, the number of CHs formation is unpredictable due to the randomly selected value m.
4. The set up phase's time duration is non-deterministic and the collisions will cause the time duration too long and hence the sensing services are interrupted. Consequently, Leach becomes unstable during the setup phase that depends on the density of sensor nodes.

3 THE PROPOSED ALGORITHM

In view of the disadvantages of LEACH, proposed algorithm plans to improve LEACH as follows:

1. The election of cluster heads is done on the basis of energy. Consequently low power nodes can't become CHs.
2. Sensor nodes use multi-hop method to communication with cluster heads. Hence, applicable to WSNs that are deployed in large regions.
3. Use of multipath-AODV routing protocol to route data from source to destination.

4 AOMDV(Ad hoc On demand Multi-path Distance Vector routing)

AOMDV lengthen AODV to provide multiple paths. AOMDV develops multiple loop-free and link-disjoint paths. In AOMDV, an alternative path to the source or destination is described by each RREQ and respectively RREP [15]. At each node, multiple paths are maintained in routing entries. The routing entries hold a list of next-hops along with corresponding hop counts for every destination. To assure loop-free paths AOMDV inaugurates the advertised hop count value at node i for destination d. This value presents the utmost hop-count available at node i for destination d. Hence, alternate paths are received only with lower hop count than the advertised hop count value for destination d available at node i. At intermediate nodes, node-disjointness is achieved by suppressing duplicate RREQ. To avoid the pioneering of very long paths between each source-destination couple the hops difference between the shortest path and the alternative paths is set to five for the all AOMDV protocol configurations.

5 Simulation and Analysis

In order to evaluate the performance of the proposed algorithm, such as network lifetime and energy consumption, the paper uses the same parameters to compare it with LEACH algorithm. The simulated model parameters are set in Fig 1.

Parameter	Values
Area of network	2000m*3000m
Number of nodes	100
Data Packet	512 Bytes
Broadcast packet	20 Bytes
Initial power	100 J

Fig. 1: Simulated Parameters

5.1 The structure of network

Due to enhance the performance of wireless sensor networks, a multi-tier multi-hop network approach was proposed to significantly reduce the routing overhead. The idea behind the multi-tier multi-hop network is to divide a very long chain-topology network into several short segments and each segment is connected to its neighbouring segments using a communication protocol. The clustering structure of the network is shown in Fig. 2.

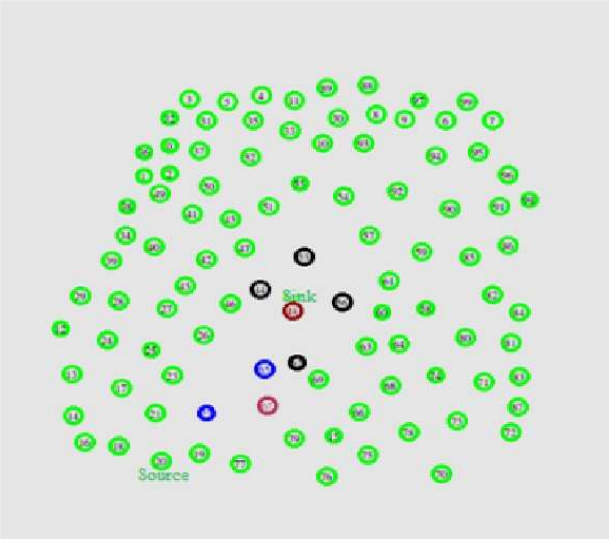

Fig. 2: Clustering

The number of total nodes is 100. The dark-red round node is the sink node deployed at centre. We set the sink node to be the tier-0 CH. The black round nodes are the cluster-heads of tier-1. After choosing the tier-1 cluster-heads source constructs multiple paths to respective tier-1 cluster-heads. Then, Routing data from tier-1 to tier-0 cluster heads.

5.2 ENERGY CONSUMPTION AND NETWORK LIFE TIME

Figure 3 illustrates the comparison of time taken during set up phase between LEACH and Proposed Algorithm. Proposed algorithm takes less time to configure the network than LEACH. Hence, consume less energy than LEACH.

Figure 4 illustrates the comparison of data transmission time between proposed algorithm and LEACH. Simulation results show that proposed algorithm communicates data for longer duration of time than LEACH. Hence the proposed algorithm has longer network life time. We define that the network lifetime is

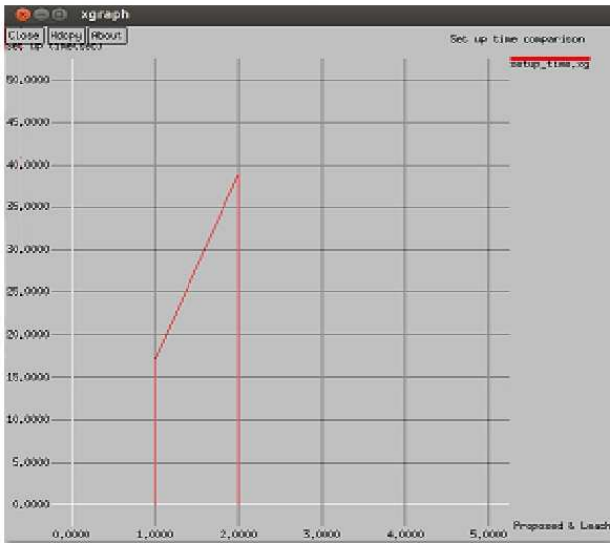

Fig. 3: Set-up time comparison

the time when the first node depletes its energy. There are three main reasons contributing the effect. One reason is that proposed algorithm chooses a cluster-head in according to energy. The second reason is that sensor nodes use multi-hop method to communication with cluster heads. The third reason is that use of multipath-AODV routing protocol to route data from source to destination.

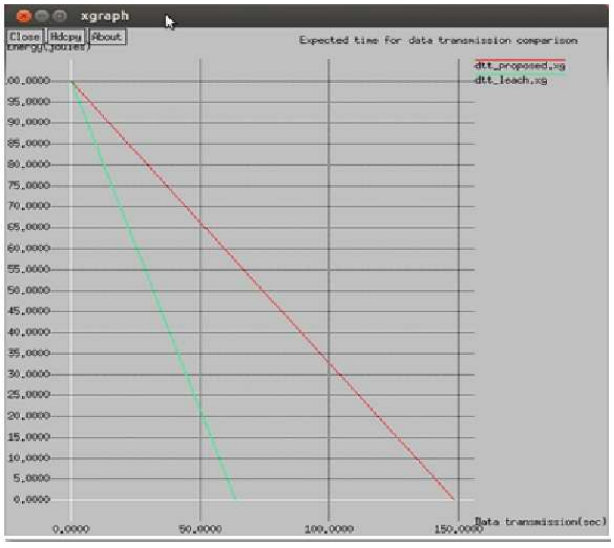

Fig. 4: Data transmission time comparison

6 CONCLUSIONS

Election of routing algorithm for wireless sensor network depends on various factors, such as scalability, bandwidth, network-delay etc. Aiming at the short comings of hierarchical routing of LEACH, the paper proposed an improved algorithm. Firstly, we adapt the formulation of selecting cluster-heads on the basis of energy that can balance the power consumption in the network and then sensor nodes use multi-hop method to communicate with cluster heads. This method avoids the sensor nodes to directly communicate with cluster-heads, thus reduces the energy consumption. In the demonstration of simulation results, the proposed algorithm provides higher performance and longer network lifetime as compare to LEACH.

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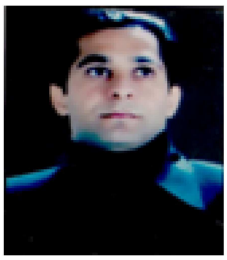

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