ISSN : 2347 - 8446 (Online)
ISSN : 2347 - 9817 (Print)
Vol. 2 Issue Special 1 Jan-March 2014
International Journal of Advanced Research in Computer Science & Technology (IJARCST 2014)

An Improved Method for Efficient Data Transmission in Wireless Sensor Networks

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Abstract
Wireless sensor networks are composed of large number of power constrained nodes, which needs an energy conservation protocols to reduce the energy consumption as much as possible. Clustering is a standard approach for achieving efficient and scalable performance in wireless sensor networks. Motivated by the former research of clustering algorithm, the objective of this project is to study an energy efficient algorithm called Multihop-LEACH.The two main concepts of this protocol are intra-cluster multihop communication and inter cluster multihop communication.

Keywords
intra-cluster, inter-cluster, power constrained

I. Introduction

In recent years, wireless sensor networks have gained worldwide attention due to the advances it made in the field of wireless communication, information technologies and electronics.Sensor networks refers to a heterogeneous system consisting of multiple detection stations called sensor nodes with a communication infrastructure intended to monitor and record conditions at diverse locations.

Wireless Sensor Networks are characterized by limited power they can harvest or store, ability to cope with node failures, heterogeneity of nodes, large scale of deployment, ability to withstand harsh environmental conditions, etc.

Due to energy constraints, a sensor node can communicate with other nodes that are within a small distance. In order to enable communication between sensors out of each other's communication range, sensors form a multi-hop communication network. Clustering sensor nodes is an effective technique for achieving multi-hop communication .Clustering facilitates distribution of control over the network. Each cluster has a cluster head (CH) , which acts as a coordinator and also some member nodes.CH gathers the data send by its respective member nodes and transmit it to Base Station(BS) through other cluster heads. Because CHs often transmit data over longer distances, they lose more energy compared to member nodes. So the network is re-clustered periodically in order to select energy-abundant nodes to serve as CHs, thus distributing the load uniformly on all the nodes. Besides achieving energy efficiency, clustering reduces network contention and packet collisions, resulting in better network throughput under high load.

The rest of this paper is organized in the following manner: Section II will introduce the main advantages and objectives of clustering,section III contains the related works,section IV contains the description of the implemented protocol.We will conclude this paper with Section V.

II. Advantages and Objectives

Clustering protocols have a wide variety of advantages over flat routing protocol. This section summarizes its advantages as well as its objectives and is as follows:

More scalability: In clustering routing scheme ,sensor nodes are grouped to form different clusters. The cluster heads are responsible for information dissemination, data aggregation and network management and the member nodes for events sensing and information collecting in their surroundings. Clustering topology can localize the route set up within the cluster and thus reduce the size of the routing table stored at the individual sensor nodes. Compared to flat topology, this kind of network topology is more scalable to respond to events in the environment and is easier to manage.

Data Aggregation: In WSN, nodes in a close area usually share same data. In cluster algorithms, CH is responsible for aggregating and transmitting data to the BS. Aggregation consists of suppressing redundancy in different data messages. So data aggregation is a way to reduce energy consumption.

Maximizing of the Network Lifetime: WSNs are composed of large number of power constrained sensor nodes and this nodes die when it run out of energy. Utilizing clustering algorithm reduces the energy consumption and thus maximize the network life cycle.

III. Related Works

LCA(Linked Cluster Algorithm), was one of the very first clustering algorithms developed. LCA was initially developed for wired sensors, but later implemented in wireless sensor networks. This algorithm avoids communication collisions among nodes and uses TDMA frames for inter-node communication, with each frame having a slot for each node in the network for communication. In the Linked Cluster Algorithm [12], a node becomes the CH if it has the highest identity among all nodes within one hop of itself or among all nodes within one hop of one of its neighbors. In LCA, each node is assigned a unique ID number and has two ways of becoming a cluster head. The first way is, if the node has the highest ID number in the set including all neighbor nodes and the node itself. The second way, assuming none of its neighbors are cluster heads, then it becomes a cluster head.

Basically, the LCA approach was designed to be used in the networks with less than 100 nodes. In such small networks, the delay between the node transmissions is minor and may be accepted. Another limitation of LCA is its relatively high control message overhead , because the nodes have to broadcast their nodes-heads list. Further, LCA does not consider the node mobility, power efficiency issues and adaptive transmission range.

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LCA2 was proposed by P. Tsigas to eliminate the election of an unnecessary number of cluster heads, as in LCA [13][14]. In LCA2, they introduce the concept of a node being covered and non-covered. A node is considered covered if one of its neighbors is a CH. CHs are elected starting with the node having the lowest ID among non-covered neighbors, ie , in LCA2 the node with the lowest id among all nodes that are neither a CH nor are within 1-hop of the already chosen CHs is elected as CH. The disadvantage of both of these linked cluster mechanisms is that the cluster head load is not uniformly distributed among all the nodes.

LEACH(Low-Energy Adaptive Clustering Hierarchy)[1] is one of the most popular clustering approaches for WSN. It is an application specific architecture. In LEACH, the nodes organize themselves into local clusters and one among them is elected as the cluster head and others as member nodes. All member nodes transmit their data to their respective CH, and on receiving data from all member nodes the cluster head performs signal processing functions on the data (e.g., data aggregation),and transmits data to the remote BS. Therefore, being a CH node is much more energy intensive than being a member node [2].

The main objective of leach is to select sensor nodes as cluster heads by rotation. In this way, the energy load of being a cluster head is evenly distributed among the nodes. The operation of LEACH is divided into rounds. Each round begins with a set-up phase followed by steady state phase. In the set-up phase the clusters are organized, while in the steady-state phase data is delivered to the BS.LEACH is a completely distributed approach and requires no global information of network. LEACH can guarantee not only the equal probability of each node as CH, but also relatively balanced energy consumption of the network nodes. However, there exist a few disadvantages in LEACH as follows:1)LEACH assumes a homogenous distribution of sensor nodes in given scenario ,which is not very realistic[3].2) Some clusters will be assigned with more number of nodes, this could makes CH nodes run out of energy quickly.3)CH have the extra burden of performing long range transmission to the distant BS, which results in too much energy consumption.

Various modifications have been made to the LEACH protocol, which form LEACH family, such as TL-LEACH [5], E-LEACH [6], M-LEACH [7], LEACH-C [8], V-LEACH [9], etc.

HEED(Hybrid Energy-Efficient Distributed clustering) [4], is a multi-hop WSN clustering algorithm which overcomes the shortcomings of unevenly distributed CH as enjoyed by the LEACH algorithm. HEED algorithm is distinguished from LEACH in CH selection mechanism. Residual energy of a node is introduced as a parameter in the CH election. In HEED, elected CHs have relatively high average residual energy compared to member nodes.

In initialization phase, nodes send the messages to compete with the initialized probability of CHprob. When the election of cluster head is completed, other nodes join into clusters by means of the information gathered in competing phase. Here, CHprob is described as ,

CHprob = max (Cprob + Eresident /Emax , pmin) where Cprob and pmin are the whole network parameters affecting the convergence speed of the algorithm, Eresident /Emax is the ratio of the node residual energy and initial energy.

In HEED,CHs send the aggregated data to the BS in a multi-hop fashion rather than single-hop fashion of LEACH. This promote more energy conservation and scalability in contrast with the single-hop fashion in the LEACH protocol.

Even so, there are some problems in HEED algorithm as follows:1) The competition of cluster head may exclude some nodes from joining into any clusters[11].2)HEED needs several iterations to form clusters which includes a lot of packet broadcast.3)The CH nodes closer to the BS consume much more energy due to the relaying network traffic near the BS. Hence the CH nodes closer to the BS may quickly exhaust battery.

IV. Multihop-Leach

It is a clustering algorithm in which,the elected CH will gather the collected data and send it to the BS either directly or via intermediate CH.Multihop-Leach[10] protocol is proposed for routing data to a network having fixed BS. It is not suitable for sensor networks where a moving source needs to be monitored. The operation of Multihop-Leach is organized into two phases:the setup phase and steady state phase.

In setup phase clusters are formed and CHs are selected.For selecting the CH,each sensor node n generates a random number between 0 and 1 and compares it to a pre-defined threshold T(n). If random<T(n),the sensor node becomes CH in that round, otherwise it is member node.

$$T(n) = \begin{cases} \frac{P}{1-P*[r \bmod (1/p)]}, & n \in G \\ 0, & \text{else} \end{cases}$$

where P is the desired percentage of CHs, r is the current round, and G is the set of nodes that have not been elected as CHs in the last 1/P rounds.

Once the CHs are elected,the steady state phase begins. During the steady phase, the sensor nodes, i.e, the non-cluster head nodes starts sensing data and sends it to their cluster-head according to the TDMA schedule. The cluster-head node, aggregates the data received from all the member nodes and then sends it to the base-station After a certain time, which is determined a priori, the network again goes back into the setup phase and new cluster-heads are chosen. Each cluster communicates using different CDMA codes in order to reduce interference from the nodes belonging to other clusters.

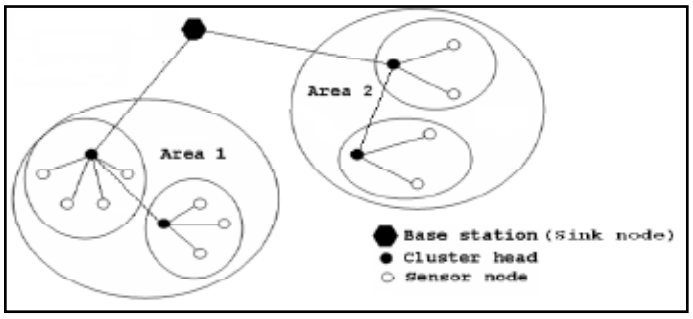

Fig. 4.1:

The two main concepts of this protocol are intra-cluster multihop communication and inter-cluster Multihop-communication.

Intra-cluster multihop communication:When the sensor nodes are deployed in dense vegetations or uneven terrain,it is better to use multihop communication among the nodes within a cluster to reach the CH as shown in figure 4.1.

Inter-cluster multihop communication:Each cluster is composed of Cluster Head and many cluster members.The cluster head gathers the collected data from cluster members and transmit it to BS.The clusters near the base station also forward the data from further clusters, because all clusters need to communicate

with the base station, but long-distance wireless communication consumes more energy.

V. Conclusion and Future Work

In recent years, wireless sensor networks have gained worldwide attention due to the advances it made in many areas such as object tracking, intrusion detection, environmental monitoring ,traffic control and so on. But the energy of network nodes is often limited, so the efficient use of energy is a must in WSN. Clustering nodes into groups not only saves energy but also reduces network contention when nodes communicate to their respective cluster-heads.

In this paper we have discussed about multihop-Leach and there exist a few disadvantages in multihop-Leach as follows:.1) Some clusters will be assigned with more number of nodes, this could makes CH nodes run out of energy quickly.2)CH is elected randomly and not based on the energy.Inorder to overcome this problem, Balanced Clustering Algorithm with Distributed Self-Organization for Wireless Sensor Networks (DSBCA), which can deal with stochastic distribution of sensor nodes can be used. The purpose of DSBCA is to generate clusters with more balanced energy and avoid creating clusters with many nodes, since, too many members in a cluster may bring about excessive energy consumption in management and communication. The clusters near the base station also forward the data from further clusters, because all clusters need to communicate with the base station, but long-distance wireless communication consumes more energy. In DSBCA a Cluster Head is selected based on the connection density, residual energy and times of being elected as Cluster Head. Thus this algorithm can enhance the network lifetime.

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